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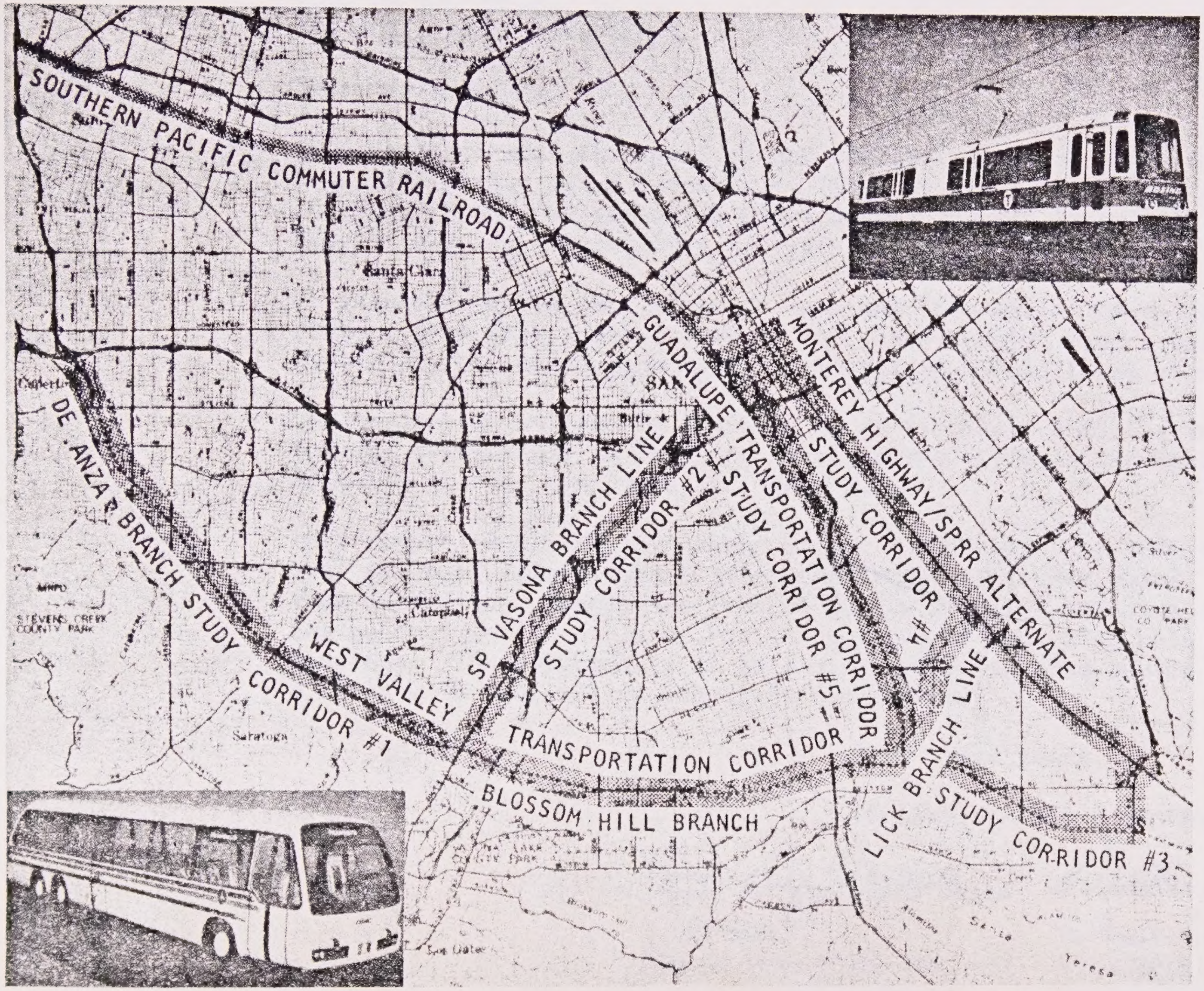
Engineers and Planners

August 1976

SANTA CLARA COUNTY TRANSIT DISTRICT



LIGHT RAIL FEASIBILITY AND ALTERNATIVES ANALYSIS

FINAL REPORT SUMMARY

6200

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August 6, 1976

PLEASE REPLY TO:
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2707-00

Mr. Louis Montini
Deputy Director for Transportation Development
Santa Clara County Transportation Agency
1555 Berger Drive
San Jose, California 95112

Dear Mr. Montini:

In accordance with the terms of our contract with the Santa Clara County Transit District dated December 1, 1975, we are pleased to transmit herewith our Final Report on the Santa Clara County Transit District Light Rail Feasibility and Alternatives Analysis.

It should be noted that wherever data and information contained in this report differs from that found in any of the seven Working Papers issued during the course of this study, the material contained herein takes precedence.

For readers whose time is limited, we particularly direct attention to the Summary section and to Chapters XIII: Basis for Decision-Making, XIV: Possible Starter Line, and XV: Next Steps.

This report concludes this phase of our assignment. We look forward to meeting over the next several months with the Transit District Board, the Transportation Commission, representatives of County and City agencies and staffs and the general public at large for the purpose of reviewing this report and its findings. The opportunity of helping to make improved public transportation a reality in Santa Clara County is appreciated.

Very truly yours,

DE LEUW, CATHER & COMPANY

I. Gilboa
Senior Vice-President
Professional Engineer
No: C22084

W. Kudlick
Vice-President
Professional Engineer
No: 0054

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ACKNOWLEDGMENTS

This study was carried out as a joint undertaking by the Staffs of the Santa Clara County Transportation and De Leuw, Cather & Company -- Engineers and Planners. Policy direction was provided by the Santa Clara County Transit District Board of Supervisors and the Santa Clara County Transportation Commission.

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(H.W. Campen and J.K. Bartholet also served as County Executive during the course of this study.)

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ACKNOWLEDGMENTS (cont.)

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In addition, the data and other support and assistance provided by numerous public agencies, utilities, private companies and individuals is gratefully acknowledged.

SUMMARY

This Light Rail Feasibility Study and Alternatives Analysis is concerned with potential transit services and alternative alignments in five designated corridors: the De Anza and Blossom Hill Road branches of the West Valley Transportation Corridor, the Southern Pacific (SP) railroad's Vasona Branch Line, the SP Lick Branch/Mainline Corridor and the Guadalupe Transportation Corridor. A variety of transit mode alternatives were evaluated: "Baseline Bus" or do-nothing possibilty, "Increased Local Bus Service," the "Bus Preferential Treatment (TSM) alternative, "Busway Transit" featuring roadways exclusively for buses and the "Light Rail Transit" alternative. Further, alternative design standards/service levels are possible with either busway or light rail transitways and these were also evaluated. These sub-alternatives were defined as "Base Case" (which is generally consistent with good, modern European light rail design and operating practices), and departures from this standard whose names are self-explanatory: "Meeting SP Requirements," "Higher Cost" and "Lower Cost."

Seven working papers were prepared during the course of the study for presentation to and discussion with the Santa Clara County Transit Board, the Santa Clara County Transportation Commission, staffs of various public agencies and the general public. These were: 1) Functional Design Criteria; 2) Travel Market Potential; 3) Alignment Definition; 4) Land Use, Socio-Economic and Environmental Considerations; 5) Patronage Forecasts; 6) Capital and Operating Costs; and 7) Alternatives Analysis. This Final Report draws upon these working papers and summarizes in one document all work undertaken, the methodologies used, major assumptions made, major problems encountered and key findings regarding the feasibility of implementing light rail transit or alternative modes in the designated study corridors.

INTRODUCTION AND PROJECT OVERVIEW

Chapter I of this report discusses the study's purpose and scope, the alternatives being evaluated, and the general assumptions underlying the study -- including such areas as land use/demographic data, 1990 highway network, fare levels, policy toward serving the handicapped, and so on -- and the criteria used for evaluating alternatives, grouped under the following headings:

- Transportation Service Effectiveness
- Economic Feasibility
- Environmental Sensitivity
- Compatibility with Local, Regional and National Goals
- Technological Suitability
- Community Acceptability and Political Support
- Financial Feasibility

CONCEPTUAL DEFINITION OF ALTERNATIVES

Chapter II consists of an expanded definition of the alternative transit modes and a description of how they would operate in the areas under study.

FUNCTIONAL DESIGN CRITERIA AND ALIGNMENT REVIEW

This chapter summarizes the major design criteria and system performance characteristics utilized in the study, including: vehicle characteristics, geometric standards, prototypical line crossections, station or stop layouts, and other data needed for plan and profile studies, cost estimates and environmental impact studies. Performance characteristics include operating patterns, maximum speeds, station or stop dwell times, minimum and policy headways, loading standards and similar information needed as inputs to the patronage analysis and for the preparation of operating cost estimates.

CAPITAL COSTS

Chapter IV outlines the costing methodology, capital cost items and corridor cost subtotals for use in corridor comparisons. A summary of the cost subtotals is shown in Table S-1 on the following page. The chapter also discusses cost comparisons between busway and light rail systems under different conditions and presents and reviews systemwide cost totals, as summarized here in Table S-2. Also contained in Chapter IV are charts showing minimum implementation time required for the various alternatives.

Table S-1 SUMMARY OF CORRIDOR CAPITAL COST SUBTOTALS

Corridor Description	Alternate	Base Case	Meeting SP Requirements	Higher Cost	Lower Cost
		(June 1976 dollars)		(Cost in $million)	
De Anza Corridor No. 1 Alternate "A" - 8.56 mi.	Light rail	47.5	53.7	57.5	42.8
	Busway	30.1	37.0	40.8	30.1
De Anza Corridor No. 1 Alternate "B" - 6.74 mi.	Light rail	32.3	36.4	40.5	28.6
	Busway	17.6	22.1	26.5	17.6
Vasona Corridor No. 2 - 6.12 mi.	Light rail	41.2	52.4	61.3	35.4
	Busway	37.0	48.5	72.2	34.2
Blossom Hill Corridor No. 3 - 9.30 mi.	Light rail	60.1	60.1	71.7	53.0
	Busway	40.1	40.1	52.7	38.2
S.P. Mainline/Lick Corridor - 7.55 mi.	Light rail	45.5	47.4	52.7	41.3
	Busway	32.0	34.2	39.5	32.0
Fourth Street RR/ Monterey Highway Alternate No. 4 - 7.78 mi.	Light rail	56.8	67.6	81.0	51.1
	Busway	43.4	55.5	69.8	40.1
Guadalupe Corridor No. 5 - 6.09 mi.	Light rail	38.1	39.2	44.5	34.7
	Busway	26.6	27.8	33.5	26.6

Table S-2 SUMMARY OF SYSTEMWIDE CAPITAL COST TOTALS

Transit Alternative	(June 1976 Dollars) (Costs in $Millions) Base Case	Meeting SP Requirements	Higher Cost	Lower Cost
Light Rail	267.5	294.0	348.0	210.4
Busway	174.2	202.7	276.1	166.2
Bus Preferential Treatment	39.6			
Increased Local Bus Service	66.7			
Baseline Bus System	68.3			

PATRONAGE FORECASTS AND EVALUATION

Chapter V contains a presentation and discussion of the 1975 and 1990 patronage estimates by mode and by corridor (see, as examples, Table S-3 and Figure S-1). Also included are results of sensitivity tests and presentation of transportation service effectiveness measures such as: modal split for selected major activity centers, impacts on parallel highway volumes and speeds and impacts on parking requirements. Accessibility/mobility measures are also analyzed, including: access to population and employment concentrations, service for transit dependents and access to major activity centers.

SYSTEM OPERATIONS, OPERATING COSTS AND FARE REVENUE ESTIMATES

Chapter VI describes how the various transit alternatives might be operated, given the ridership forecasts presented previously. Vehicle fleet size and vehicle-mile and vehicle-hour operating statistics are then derived from the possible operating patterns, resulting in annual operating cost estimates, as summarized in Table S-4. Also included in this chapter are the estimated costs of purchasing transit services from the SP railroad in order to permit free transfer arrangements for Intra-County transit riders, the annual fare revenues for the various transit alternatives (assuming a 25-cent base fare) and the percent of operating costs estimated to be recovered from farebox revenues (see Table S-4).

ENVIRONMENTAL ASSESSMENT

Chapter VII features a discussion of the impact the alternatives are likely to have with respect to such land use areas as joint station/building opportunities, collateral development possibilities and station area land use impact. Socio-economic evaluations presented and discussed in Chapter VII involve community services, relocation requirements, economic pressure around stations, neighborhood character and equity considerations. Also discussed are natural environment considerations such as air quality, energy, noise, visual, ecosystem, water resources, soils and geology, parks and open space and historic and archaeological sites.

Table S-3
1990 SYSTEMWIDE TRANSIT PATRONAGE FORECASTS BY MODE

Alternative	Peak-Hour Trips		Daily Trips	
	By Transit	% of Total	By Transit	% of Total
Baseline Bus (516-Bus Fleet)	15,000	3.8	120,000	2.0
Low-Capital-Cost Improved Bus				
• 1000-Bus Fleet	24,000	6.0	170,000	2.8
• Bus Preferential Treatment (TSM)	20,000	5.0	140,000	2.3
Busway Transit				
• On Busway	8,700	2.2	60,000	1.0
• On Local Buses	11,300	2.8	90,000	1.5
System Total	20,000	5.0	150,000	2.5
Light Rail				
• On Light Rail	10,000	2.6	70,000	1.2
• On Local Buses	11,500	2.9	90,000	1.5
System Total	21,500	5.5	160,000	2.7

De Leuw, Cather & Company

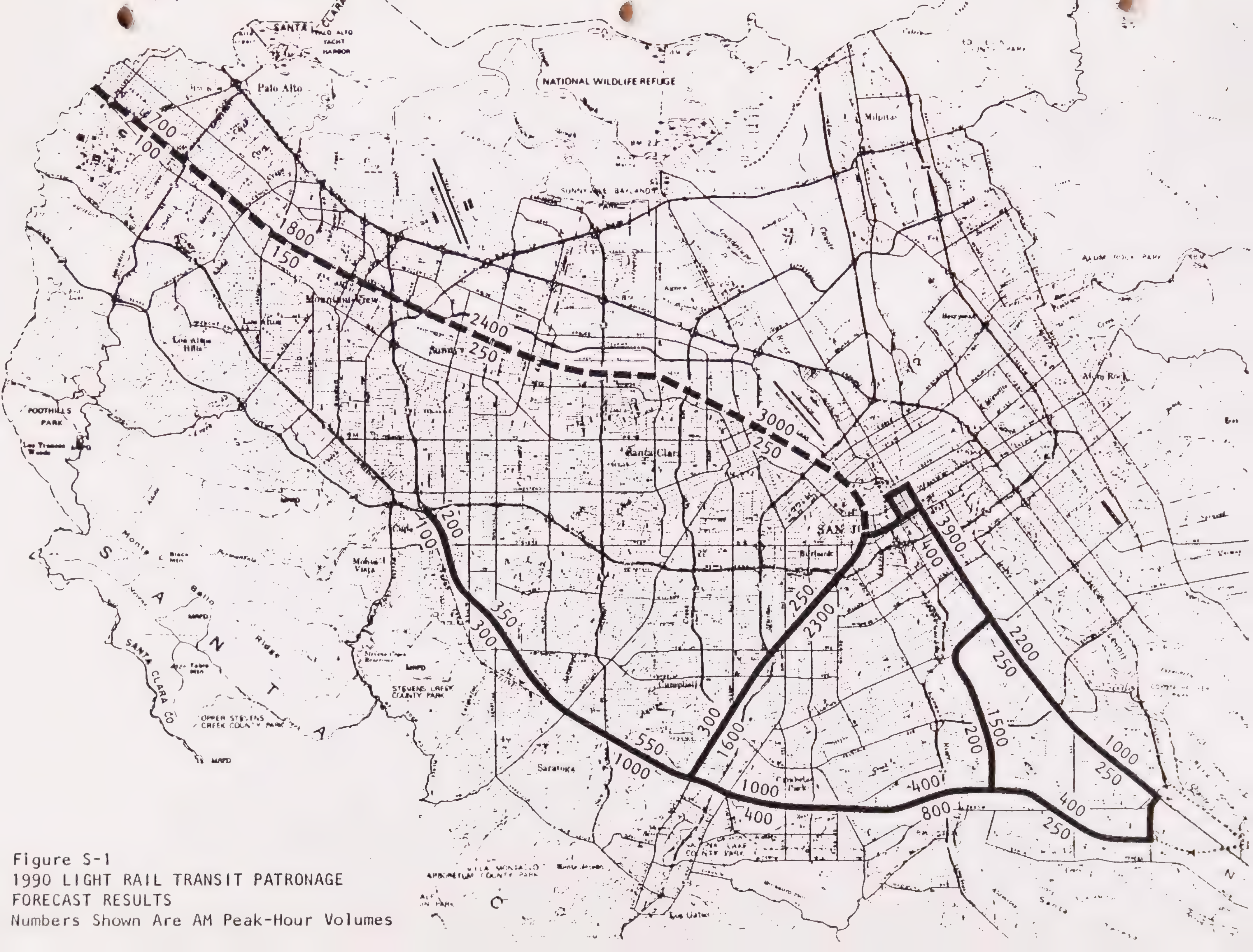

Figure S-1
1990 LIGHT RAIL TRANSIT PATRONAGE
FORECAST RESULTS
Numbers Shown Are AM Peak-Hour Volumes

Table S-4
PERCENT OF OPERATING COSTS RECOVERED FROM FAREBOX REVENUES

Transit Alternative	Annual Operating Costs*	Annual Farebox Receipts	Percent Farebox/ Operating Costs
Baseline Bus	$38.60	$5.83	15.1
Increased Local Bus	72.60	8.26	11.3
Bus Preferential Treatment			
Local Bus	38.60	5.15	13.3
Preferential Bus	11.60	1.65	14.2
Busway Transit			
Local Bus	38.60	4.86	12.6
Busway	10.30	2.43	23.6
Light Rail Transit			
Local Bus	38.60	4.86	12.6
Light Rail	8.73	2.92	33.0

*Operating costs for transitway/express bus portions include SPRR "purchase of services" costs.

The relative results for alternative transit modes and corridors are summarized graphically in Figures S-2 and S-3 on the following pages. Analysis indicated no insurmountable land use, socio-economic or natural environmental constraints which would automatically preclude any particular mode or corridor, though there are sensitive locations in each corridor which will require special precautions to avoid undesirable effects and these will vary according to the mode selected for implementation.

ECONOMIC FEASIBILITY

This chapter features both a benefit-cost analysis for each of the alternative modes and additional economic efficiency crtieria such as costs per passenger and per passenger-mile and annual subsidy requirements. Two types of benefits were evaluated, primary benefits and potential "add-on" benefits. Primary benfits were: constant transit user time savings, non-diverted auto user time savings, diverted auto user automobile and operating and maintenance (O & M) cost savings, parking cost savings, reduced highway accidents and commercial vehicle time savings. The potential "add-on" benefits were those which might be attributable to containment of urban sprawl, reduction in automobile ownership and time savings for non-work trips. Discount rates of seven percent, four percent and ten percent were used in view of the current lack of unanimity regarding the appropriate discount value for studies of this kind.

Benefit-cost ratios for the alternatives and sub-alternatives, both without and with the potential "add-on" benefits, can be seen in Table S-5. It will be noted that on the basis of primary benefits only, none of the alternatives have benefit-cost ratios greater than 1.0 at seven percent or ten percent discount rates. At a four percent rate, both the busway and light rail systems exceed 1.0. If the potential additional benefits are included, the busway and light rail benefit-cost ratios exceed 1.2, even with a seven percent discount rate.

The transit efficiency measures used as economic criteria are summarized in Tables S-6 and S-7.

With respect to transit efficiency measures, the baseline bus has the lowest capital cost per passenger ($0.21) and per passenger-mile ($0.05), while light rail is highest at $0.61 and $0.11, respectively. The situation is different, however, in regard to operating cost, where the light rail ranks best at $1.11 per passenger and $0.20 per passenger-mile (versus $1.13 and $0.25 for the baseline bus). Considering combined capital and operating cost,

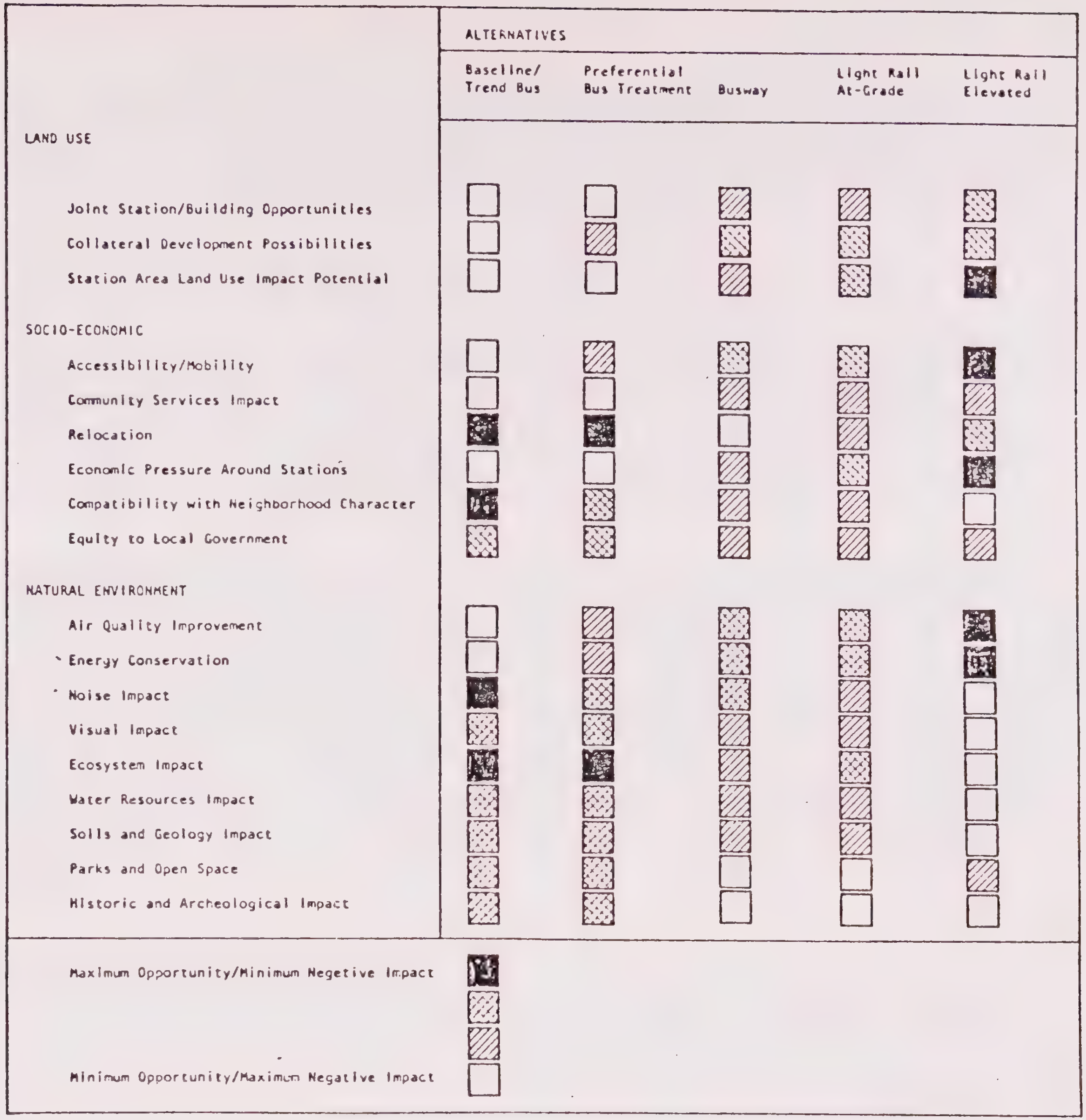

Figure S-2
COMPARISON OF ENVIRONMENTAL CONSIDERATION BY ALTERNATIVE TRANSIT MODES

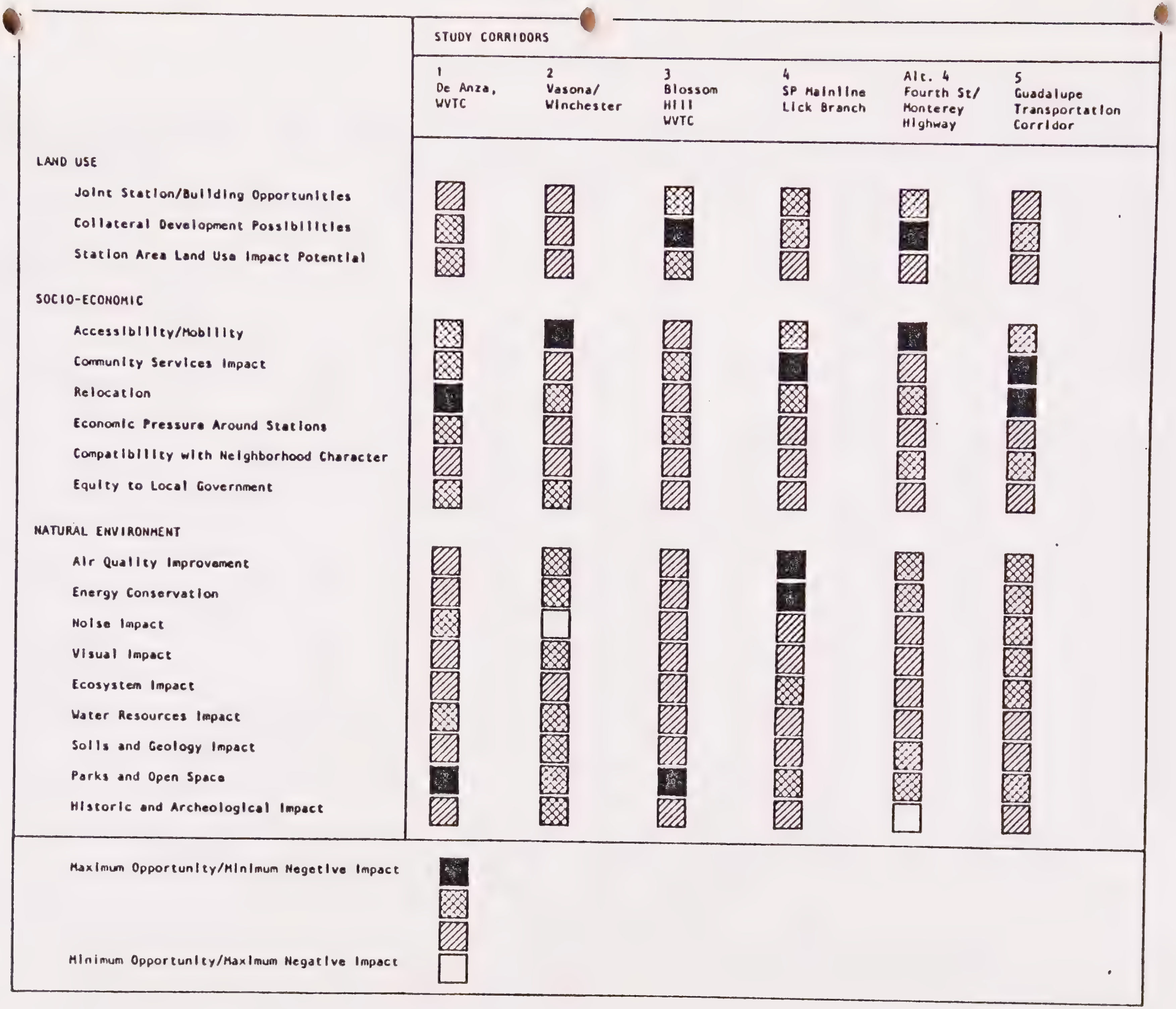

Figure S-3
COMPARISON OF ENVIRONMENTAL CONSIDERATIONS BY CORRIDOR

Table S-5
1990 BENEFIT-COST RATIOS WITHOUT AND WITH POTENTIAL ADDITIONAL BENEFITS

Benefits/Costs*	Base Case					Sub-Alternatives					
						Lower Cost		SP/PUC Requirements		Higher Cost	
	Baseline Bus	Bus Pref.	Expanded Bus	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail
Without Potential Additional Benefits											
7% Discount Rate											
Annual Benefits	--	8.94	24.38	20.58	25.84	16.26	20.58	20.58	25.84	29.75	32.55
Annualized Costs	45.98	15.22	41.03	24.03	29.14	22.33	24.71	26.17	31.14	32.57	35.87
Benefit-Cost Ratio	--	0.59	0.59	0.86	0.87	0.73	0.83	0.77	0.83	0.91	0.91
4% Discount Rate											
Annual Benefits	--	8.94	24.38	20.58	25.84	16.26	20.58	20.58	25.84	29.75	32.55
Annualized Costs	44.49	14.31	39.62	19.84	22.67	18.33	19.58	21.28	24.02	25.88	27.43
Benefit-Cost Ratio	--	0.62	0.62	1.04	1.14	0.89	1.05	0.97	1.08	1.15	1.19
10% Discount Rate											
Annual Benefits	--	8.94	24.38	20.58	25.84	16.26	20.58	20.58	25.84	29.75	32.55
Annualized Costs	47.61	16.21	42.58	28.74	36.33	26.78	30.43	31.61	39.06	40.02	45.25
Benefit-Cost Ratio	--	0.55	0.57	0.72	0.71	0.61	0.68	0.65	0.66	0.74	0.72
With Potential Additional Benefits											
7% Discount Rate											
Annual Benefits	--	11.66	32.74	29.59	36.25	24.16	29.59	29.59	36.25	41.04	44.22
Annualized Costs	45.98	15.22	41.03	24.03	29.14	22.33	24.71	26.17	31.14	32.57	35.87
Benefit-Cost Ratio	--	0.77	0.80	1.23	1.24	1.08	1.20	1.13	1.16	1.26	1.24

* Benefits and costs are marginal; expressed in millions of 1976 dollars

TRANSIT ECONOMIC EFFICIENCY MEASURES -- SYSTEM COSTS

	Base Case					Sub-Alternatives					
						Lower Cost		SP/PUC Requirements		Higher Cost	
	Baseline Bus	Bus Pref.	Expanded Bus	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail
Total System Annual Passenger Trips (millions)	34.3	40.0	48.6	42.9	45.8	41.5	42.9	42.9	45.8	47.2	48.6
Total System Annual Passenger Miles (millions)	154.4	208.8	218.8	236.0	256.0	234.5	236.0	236.0	256.0	266.0	276.0
Incremental Annual Passenger Trips (millions)	--	5.7	14.3	8.6	11.5	7.2	8.6	8.6	11.5	12.9	14.3
Incremental Annual Passenger Miles (millions)	--	54.3	64.4	81.5	101.5	80.1	81.5	81.5	101.5	111.5	121.6
Annual Cost in 1976 Dollars per 1990 Passenger-Trip and 1990 Passenger-Mile											
Total System Capital Cost/Passenger	$0.21	$0.27	$0.30	$0.49	$0.61	$0.49	$0.54	$0.54	$0.65	$0.61	$0.70
Total System Capital Cost/Passenger-Mile	0.05	0.05	0.07	0.09	0.11	0.09	0.10	0.10	0.12	0.11	0.12
Incremental Over Base Marginal Cost/Passenger	--	0.63	0.49	1.60	1.79	1.84	1.85	1.85	1.96	1.66	1.85
Marginal Cost/ Passenger Mile	--	0.07	0.11	0.17	0.20	0.16	0.19	0.19	0.22	0.19	0.22
Total System O+M Cost/ Passenger	1.13	1.34	1.56	1.22	1.11	1.23	1.18	1.22	1.11	1.13	1.06
Total System O+M Cost/ Passenger-Mile	0.25	0.26	0.35	0.22	0.20	0.22	0.22	0.22	0.20	0.20	0.19
Incremental Over Base Marginal Cost/Passenger	--	2.03	2.38	1.20	0.76	1.29	1.03	1.20	0.76	0.87	0.66
Marginal Cost/ Passenger-Mile	--	0.21	0.53	0.13	0.09	0.11	0.11	0.13	0.09	0.11	0.08
Total System Cost Total Cost/Passenger	$1.34	$1.61	$1.86	$1.71	$1.72	$1.72	$1.72	$1.76	$1.76	$1.74	$1.76
Total Cost/Passenger-Mile	0.30	0.31	0.42	0.31	0.31	0.31	0.32	0.32	0.32	0.31	0.31
Incremental Over Base Marginal Cost/Passenger	--	2.66	2.87	2.80	2.55	3.13	2.88	3.05	2.72	2.53	2.52
Marginal Cost/ Passenger-Mile	--	0.28	0.64	0.30	0.29	0.27	0.30	0.32	0.31	0.30	0.30

Table S-7
TRANSIT EFFICIENCY -- SUBSIDY REQUIREMENTS
Annual Cost in 1976 Dollars per 1990 Passenger-Trip and Passenger-Mile

	Base Case					Sub-Alternatives					
						Lower Cost		SP/PUC Requirements		Higher Cost	
	Baseline Bus	Bus Pref.	Expanded Bus	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail
System Subsidy Requirements*											
O & M Costs (incl. SP Service)	38.60	53.60	76.00	52.30	50.70	51.20	50.85	52.30	50.70	53.20	51.40
Fare Revenues	5.83	6.80	8.26	7.29	7.78	6.92	7.29	7.29	7.78	8.06	8.26
Subsidy Required	32.77	46.80	67.74	45.01	42.92	44.28	43.56	45.01	42.92	45.14	43.14
Subsidy/Passenger	0.96	1.17	1.39	1.05	0.94	1.07	1.01	1.05	0.94	0.96	0.89
Subsidy/Passenger-Mile	0.21	0.22	0.31	0.19	0.17	0.19	0.18	0.19	0.17	0.17	0.16
Incremental Subsidy**											
O & M Costs (incl. SP Service)	--	11.60	34.00	10.30	8.70	9.20	8.85	10.30	8.70	11.20	9.40
Fare Revenues	--	0.97	2.43	1.46	1.95	1.09	1.46	1.46	1.95	2.23	2.43
Subsidy	--	10.63	31.57	8.84	6.75	8.11	7.39	8.84	6.75	8.97	6.97
Subsidy/Passenger	--	1.86	2.21	1.03	0.59	1.13	0.86	1.03	0.59	0.70	0.49
Subsidy/Passenger-Mile	--	0.20	0.49	0.11	0.07	0.10	0.09	0.11	0.07	0.08	0.06

Note: All Figures are Millions of Dollars except per Passenger and per Passenger-Mile Figures.

* Baseline bus costs and revenues included in all alternatives.

** Costs and revenues are the costs/revenues accrued as a result of alternative implementation. These figures do not include base bus figures.

the baseline bus does considerably better on a cost-per-passenger basis ($1.34 vs. $[illegible].51 for the next best) but only very slightly better than all the others on a cost-per-passenger-mile basis. With respect to subsidy requirements, light rail -- because of its higher patronage (and hence revenue) and lower operating cost -- is lower than all other alternatives, including the next best baseline bus, on both a per-passenger basis ($0.94 vs. $0.96) and a per-passenger-mile basis ($0.17 vs. $0.21).

GOALS ACHIEVEMENT

Chapter IX reviews the applicable national, regional and local goals and discusses the relative ability of the transit alternatives under study to assist in attaining these goals. It was found that all of the alternatives, if properly designed and implemented, can help achieve a variety of the stated goals. Some will perform better in certain areas than others, while none is to be expressly preferred on all counts. It is difficult, therefore, to summarize this aspect of the analysis, but on balance, it appears that the two transitway systems (busway and light rail) are to be preferred to all other alternatives.

FINANCIAL FEASIBILITY

The analysis summarized in Chapter X indicated that the capital funds available (as estimated by the Santa Clara County Transportation Agency staff) will be inadequate to meet the full, five-corridor implementation costs of any of the alternatives except the baseline bus and bus preferential treatment (TSM). Deficits range from $10.5 million (in inflated dollars) for the expanded local bus fleet to $280.1 million for the light rail system if lines were to be constructed in all corridors studied (see Table S-8). It should be noted that the specified funding constraints are based on the assumption that 80 percent of the cost of system implementation will be met by the Federal government -- an assumption which may or may not be valid considering the limited monies currently available and the competition among regions for these Federal funds. Also because of the restrictions placed on the uses of SCA-15 monies for "fixed guideway" facilities only, it does not appear at this time that these funds could be used to match Federal funds to construct bus or busway improvements. Therefore, it appears that only $67.5 million would be available to construct bus or busway improvements, whereas $101.7 million would be available to implement a light rail transit system.

The Transit District Board recognized this funding difficulty prior to the March 1976 sales tax election, and while realizing that passage of the 1/2-cent sales tax measure would not permit the installation and continued operation of the full five-corridor system, the Board was informed that a ten to fifteen mile useful first segment could be constructed and operated within the projected funding constraints.

Table S-8
INCREMENTAL CAPITAL COST FINANCING NEEDS FOR SYSTEM EMPLEMENTATION
(In millions of inflated dollars)

	Base Case					Sub-Alternatives					
						Lower Cost		SP/PUC Requirements		Higher Cost	
	Baseline Bus	Bus Pref.	Expanded Bus	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail
Total Capital Cost	39.9*	47.7	78.0	239.1	381.8	227.8	299.7	279.7	420.6	382.5	498.9
Capital Cost Constraint	39.9*	67.5	67.5	67.5	101.7	67.5	101.7	67.5	101.7	67.5	101.7
Possible Shortfall in Capital Costs	--	--	10.5	171.6	280.1	160.3	198.0	212.2	318.9	315.0	397.2
Additional Local Capital Required (assumes 80% Federal funding)	--	--	2.1	34.3	56.0	32.1	39.6	42.4	63.8	63.0	78.8

* According to District's current 5-year T.I.P. issued December 1975

The situation is even worse with respect to annual operating and maintenance costs (see Table S-9). It appears that only the baseline bus alternative can meet the given constraint. The light rail system, because of its higher patronage (and hence greater farebox revenue) and lower operating cost, has the least shortfall of all the alternatives.

Table S-9
INCREMENTAL OPERATING COST FIANACING NEEDS FY 1981 - 1985
(In millions of inflated dollars)

	Base Case					Sub-Alternatives					
						Lower Cost		SP/PUC Requirements		Higher Cost	
	Baseline Bus	Bus Pref.	Expanded Bus	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail
Operating Costs	311.3	93.5	274.2	68.9	45.0	61.3	45.7	68.9	45.0	74.8	48.6
Fares	47.1	8.0	19.6	9.9	10.2	7.0	7.5	9.9	10.2	15.0	13.8
Subsidy Requirement	264.3	85.5	254.6	59.0	34.8	54.3	38.2	59.0	34.8	59.8	34.8
Subsidy Constraint	282.3	14.3	14.3	14.3	20.2	14.3	20.2	14.3	20.2	14.3	20.2
Possible Shortfall in Operating Funds FY 1981 through 1985	--	71.2	240.3	44.7	14.6	40.0	18.0	44.7	14.6	45.5	14.6

TECHNOLOGICAL SUITABILITY

The use of proven, mature bus and rail technologies resulted in the finding that the measures of safety, technical risk, flexibility and growth potential, procurement risk and service dependability were virtually equal for all alternatives.

COMMUNITY ACCEPTABILITY AND POLITICAL SUPPORT

As discussed in Chapter XII, the scheduled community meetings and reviews of this study's findings over the next three months are expected to lead to recommendation of a Final Action Plan by the Transportation Commission and approval of such a plan by the Transit District Board. These actions will provide the best indication of how the alternatives compare with respect to this evaluation area. Based on the results of public meetings to date and the voter approval of the 1/2-cent sales tax in support of transit, baseline bus and light rail appear to the Consultant to be the preferred alternatives from the local point of view. The degree of acceptance and support of these or other alternatives at the regional and national levels is uncertain at present and can only be resolved over time as these levels of government respond to local initiatives seeking plan funding and implementation.

BASIS FOR DECISION-MAKING

Chapter XIII illustrates a procedure whereby each decision-maker, using individual value judgments and sense of priorities, can carry out a trade-off analysis both among the measures within a given evaluation area and among the seven major evaluation areas, leading to some final conclusions as the end result of this study and evaluation process. The basic questions to be answered are:

- Which of the alternative modes or combinations of modes should be selected for implementation in Santa Clara County on a systems basis?

- If either the busway or light rail mode alternative should be selected, what is the most appropriate design standard/service level option for near-term implementation (i.e., in the next five to ten years)?

- Assuming that not all of the corridors are equally attractive, what are their relative priorities for implementation?

To illustrate the process, the Consultant has prepared the summary comparison of evaluation measures shown in Tables S-10, S-11 and S-12 based on their own value judgments as to what factors are most significant, the relative rankings indicated by the data developed in the course of the study, and trade-off analysis between conflicting objectives. It is hoped that each concerned decision-maker will follow a similar procedure to arrive at his own informed conclusions using the data and supporting material contained in the project's seven working papers and this final report.

It was concluded by the Consultant that:

- All of the mode alternatives have some positive features which recommend them in one or more evaluation areas.

- Light rail and baseline bus, being preferred in numerous categories, are the two most desirable alternatives.

- Only the baseline bus system satisfies the given capital and operating constraints. If light rail is to be considered further, therefore, it must be on a basis of less than full implementation in all study corridors.

- A logical basis for a starter line would be the Guadalupe/Monterey Highway/Lick Branch corridor with a design standard/service level corresponding to the base case or meeting SP requirements options.

The rationale for the selection of a possible starter line is presented toward the end of Chapter XIII. In addition to citing data supporting the choice, it is pointed out that while technical studies such as this one can help to define the issues and quantify benefits, costs and the consequences of alternative actions, in the final analysis the choice is dependent not on technical information alone, but on the unique and special way the County perceives itself and the future toward which it wishes to move.

S-10

SUMMARY OF MODE ALTERNATIVE EVALUATION MEASURES

Evaluation Measures	Baseline Bus	Expanded Local Bus	Bus Pref. Treatment	Busway	Light Rail
TRANSPORTATION SERVICE					
Patronage & Modal Split		//////			//////
Mobility/Accessibility		//////		//////	//////
Highway & Parking Impact				//////	//////
ECONOMIC FEASIBILITY					
Annual Benefits		//////			//////
Combined Capital & Oper. Costs			//////		
Benefit-Cost Ratio				//////	//////
Combined Cost/Passenger	//////				
Combined Cost/Passenger-Mile	//////		//////	//////	//////
ENVIRONMENTAL SENSITIVITY					
General Plan Compatibility	//////	//////			
Directing Urban Growth					//////
Socio-economic Impact		//////			
Natural Environment Impact	//////	//////			
FINANCIAL FEASIBILITY					
Capital Cost Constraint	//////		//////		
Operating Cost Constraint	//////				
Subsidy Required/Passenger	//////				//////
GOALS ACHIEVEMENT					
National				//////	//////
Regional				//////	//////
Local				//////	//////
TECHNOLOGICAL SUITABILITY					
Composite Performance					
COMMUNITY SUPPORT					
Public	//////				//////
Political Leaders	//////				//////

Legend: ////// Preferred/Performs Best in Consultant's Judgment
(Lack of any box shaded indicates no clear choice.)

SUMMARY OF DESIGN STANDARD/SERVICE LEVEL EVALUATION MEASURES

Evaluation Measures	Base Case	Meeting SP/PUC Requirements	Higher Cost	Lower Cost
TRANSPORTATION SERVICE				
Patronage & Modal Split			//////////	
Mobility/Accessibility			//////////	
Highway & Parking Impact			//////////	
ECONOMIC FEASIBILITY				
Annual Benefits			//////////	
Combined Capital & Oper. Costs				//////////
Benefit-Cost Ratio			//////////	
Combined Cost/Passenger				
Combined Cost/Passenger-Mile				
ENVIRONMENTAL SENSITIVITY				
General Plan Compatibility				
Directing Urban Growth			//////////	
Socio-economic Impact			//////////	
Natural Environment Impact				//////////
FINANCIAL FEASIBILITY				
Capital Cost Constraint				//////////
Operating Cost Constraint				//////////
Subsidy Required/Passenger				//////////
GOALS ACHIEVEMENT				
National			//////////	
Regional			//////////	
Local			//////////	
TECHNOLOGICAL SUITABILITY				
Composite Performance		//////////	//////////	
COMMUNITY SUPPORT				
Public	//////////			
Political Leaders	//////////			

Legend: ////////// Preferred/Performs Best in Consultant's Judgment
(Lack of any box shaded indicates no clear choice.)

S-12

SUMMARY OF CORRIDOR EVALUATION MEASURES

Evaluation Measures	De Anza Branch WVTC	Vasona Branch	Blossom Hill WVTC	Guadalupe/ Monterey/Lick
TRANSPORTATION SERVICE				
Patronage & Modal Split				//////////
Mobility/Accessibility		//////////		//////////
Highway & Parking Impact				//////////
ECONOMIC FEASIBILITY				
Annual Benefits				
Combined Capital & Oper. Cost				
Benefit-Cost Ratio				
Combined Cost/Passenger				
Combined Cost/Passenger-Mile				
ENVIRONMENTAL SENSITIVITY				
General Plan Compatibility				
Directing Urban Growth		//////////		//////////
Socio-economic Impact		//////////		//////////
Natural Environment Impact				
FINANCIAL FEASIBILITY				
Capital Cost Constraint				
Operating Cost Constraint				
Subsidy Required/Passenger				
GOALS ACHIEVEMENT				
National				
Regional				
Local				
TECHNOLOGICAL SUITABILITY				
Composite Performance				
COMMUNITY SUPPORT				
Public				
Political Leaders				

Legend: ////////// Preferred/Performs Best in Consultant's Judgment
(Lack of any box shaded indicates no clear choice.)

STARTER LINE

Chapter XIV further discusses the capital and operating cost constraints and indicates how a possible starter line consistent with these constraints might be selected. Figure S-4 shows a possible light rail starter line alignment which was designated for illustrative purposes. Analysis of this possible starter line indicated it would satisfy the capital cost limitations if Federal funding were provided but the possible line would cost about $1.6 million more to operate (including purchase of services from the SP railroad) than is currently available under the existing five year financial plans. Assuming a 25-cent base fare, it is estimated that only about 24 percent of the total operating cost would be recovered from the farebox by the starter line.

A benefit-cost anlaysis was made for the potential starter line assuming a seven percent discount rate. It was found that the ratio would be about 0.9 if only primary benefits were considered and about 1.3 if the possible "add-on" benefits were included. Again, if suitable land use changes were instituted in conjunction with the installation of the light rail line and if other supporting actions were carried out, a considerable increase in patronage (and, consequently, a significant increase in the benefit-cost ratio) would be expected.

Transit efficiency measures were also computed for the possible starter line and compared with the baseline bus alternative. These again highlight the choice that exists between capital-cost intensive transit systems and operating-cost intensive systems. It was concluded that the rationale for selection of a light rail starter line presented at the end of the previous chapter (Basis for Decision-Making) was still valid. Obviously, however, further refinement will be required before an optimum initial line segment is designated for implementation.

NEXT STEPS

Chapter XV concludes this report with a review of the actions scheduled to be taken between now and the end of March, 1977, when the Final EIR, Summary and Action Plan are scheduled to be incorporated into the County's Transportation Improvement Program (T.I.P.) for

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- - - Existing Regional Rapid Transit Line (SPRR)

——— Possible Light Rail Starter Line

········ Possible Light Rail Extensions

● Station/Stops

▣ Proposed New Regional Transportation Terminal

Figure S-4
POSSIBLE LIGHT RAIL STARTER
LINE ALIGNMENT

transmittal to MTC for inclusion in the regional T.I.P. Chapter XV also reviews the relationship of this study to MTC's Peninsula Transit Alternatives Project (PENTAP) and to the ABAG/MTC Santa Clara Valley Corridor Study.

Finally, the desirability of seeking an early UMTA reaction to the findings of this light rail feasibility study and alternatives analysis is stressed. Much, if not all, of the information in which UMTA has based funding decisions in other cities is now available for Santa Clara County. An early reaction by UMTA could be instrumental in helping to avoid the wasting of scarce funds on pointless additional studies and/or could help focus the County's future efforts most productively.

CHAPTER I

INTRODUCTION AND PROJECT OVERVIEW

This is the Final Report summarizing all work undertaken and the key findings of the Light Rail Feasibility and Alternatives Analysis project being conducted jointly by De Leuw, Cather & Company (DCCO) and the Santa Clara County Transportation Agency (SCCTA) for the Santa Clara County Transit District (SCCTD). This project involves a study of the engineering and economic feasibility of implementing light rail and/or other transit alternatives within five designated study corridors which are representative of typical conditions encountered in Santa Clara County.

STUDY CORRIDORS

The five study corridors designated for the study by the SCCTD Board are depicted on the map shown in Figure 1 and can be generally described as follows:

- Study Corridor 1 - De Anza Branch of the West Valley Transportation Corridor, Cupertino to Vasona Junction.
- Study Corridor 2 - SP Vasona Branch RR Line, Vasona Junction to central San Jose.
- Study Corridor 3 - Blossom Hill Road Branch of the West Valley Transportation Corridor, Vasona Junction to IBM.
- Study Corridor 4 - SP Lick Branch RR Line and the SP Mainline RR, West Valley Transportation Corridor to central San Jose; an alternate would connect IBM and central San Jose along the Monterey Highway and the SP 4th Street RR lines.

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Figure 1
LOCATION OF STUDY CORRIDORS FOR LIGHT RAIL FEASIBILITY AND ALTERNATIVES ANALYSIS PROJECT

- Study Corridor 5 - Guadalupe Transportation Corridor, West Valley Transportation Corridor to central San Jose.

STUDY PURPOSE AND SCOPE

The making of informed public policy decisions in regard to possible light rail or alternative transit system implementation within each corridor requires consideration of such factors as: construction and operating feasibility, order-of-magnitude capital and operating costs, potential ability to attract travelers in the corridors, interaction with the existing rail and highway systems, and the possible socio-economic, environmental and land use impacts. Only an initial assessment of light rail system feasibility, together with an analysis of transit alternatives, is required at this time; additional and/or more refined studies can be undertaken at a later date if they appear to be warranted as a result of the investigation just carried out.

Seven working papers were issued during the course of the project and are listed below:

1. Functional Design Criteria
2. Travel Market Potential
3. Alignment Definition
4. Land Use, Socio-Economic and Environmental Considerations
5. Patronage Forecasts
6. Capital and Operating Costs
7. Alternatives Analysis

Each working paper was intended to provide important information to the general public and public agencies upon completion of a significant block of work-in-progress so that the study staff and its policy-making Board could benefit from reactions and other inputs from these groups.

Included were such major subject areas as the definition and description of transit alternatives to be considered and their functional design criteria, operating characteristics and policies, general assumptions, a description of the alternatives analysis framework and evaluation criteria to be used, transit travel market potential, transitway alignment definition and station location, preliminary environmental impact assessment, system operations and estimated ridership, capital and operating cost estimates, and analysis and comparison of the transit system alternatives. This is the final report issued at the conclusion of the study. It summarizes all the work undertaken, the methodologies used, major assumptions made, major problem areas encountered and the key findings regarding the feasibility of implementing light rail transit in the five designated corridors.

ALTERNATIVES BEING EVALUATED

The alternatives included in this project were defined and described in some detail in Working Paper 1. Briefly, they are the following:

- Baseline Bus or "Do Nothing" Alternative - Assumes a continuation of the present transit policies and service levels. This alternative also constitutes a reference point for comparing other systems.

- Bus Preferential Treatment (TSM) - This alternative consists of an expanded bus fleet and relatively low capital cost improve ments designed to provide better transit on existing streets and highways. Measures to be considered include increased exclusive bus lanes, bus streets, bus priority at traffic signals, and traffic engineering improvements.

- Busway Rapid Transit - This alternative would result in the construction of exclusive bus roadways with bus preferential treatments at all grade crossings resulting in a high speed, bus rapid transit system.

- Light Rail Transit - This system is a modern-day version of the former interurban street car service which once existed in Santa Clara County. Depending on the design standards and the degree of at-grade street crossings allowed, service levels and system costs can approach either those of high speed, conventional rail rapid transit systems or, at the other extreme, the simple electric trolley cars which formerly operated in numerous American cities. This study examined the trade-offs possible between these two extreme light rail design cases.

In addition, a number of sub-alternatives were defined to bracket the range of possible design standards/service level options which exist with respect to busway and light rail transit systems. These are:

- "Base Case". This option represents a workable solution which could be implemented with a fairly high degree of safety. It does not however, always meet PUC regulations or SP railroad requirements as they now stand and thus the feasibility of some of its assumptions has not been verified. This option is generally consistent, however, with good, modern European light rail design practice.

- "Meeting SP Requirements". This design standard is essentially the same as the "Base Case" except that it provides for grade separation of railroad and transit facilities at all railroad crossings (including spur tracks) and would require using a separate, fenced right-of-way when the transit way alignment is at-grade and adjacent to railroad line.

- "Higher Cost". This design standard is the same as for the "Base Case", with additional grade separations at all major streets

and at all railroad branch lines (still includes some at-grade crossings of railroad spur tracks and minor streets), plus the addition of greater amenities and architectural standards at stations and an increase in the amount of landscaping provided.

- "Lower Cost". This option assumes a minimal cost system, with right-of-way and structures shared with the railroad where possible; grade separations only at freeways and railroad mainline crossings; minimal signalizations without automatic train protection for the light rail system; and utilization of reconditioned used PCC cars rather than the purchase of new light rail vehicles.

GENERAL ASSUMPTIONS

In order to analyze and evaluate alternative transit systems within the five study corridors in Santa Clara County, a number of basic assumptions are necessary. These general assumptions include the design philosophy, Countywide land use plans and set of demographic projections, a highway network and highway capacity assumptions, automobile operating costs and travel speeds, a local background bus system and service level, and other more policy-oriented assumptions dealing with fare levels, fare collection, handicapped service, the railroad and the California Public Utility Commission (PUC) rules and regulations, and environmental and economic factors. These general assumptions are needed to formulate operating policies, estimate costs, estimate potential ridership and evaluate potential economic and environmental costs and benefits. An initial set of general assumptions was set down in Working Paper 1 for study purposes, and was subsequently refined and modified as the project progressed and more information became available, and in response to direction from the Transit District Board and in response to public and public agency suggestions.

Key assumptions made in this project are summarized below:

Land Use/Demographic Data. The best currently available information was used. That is, the Santa Clara County Transportation Planning Study, completed in 1969, provided forecasts of land use, population and employment for 1975 and 1990 based on projections made from a 1966 data base. The 1975 forecasts were used as is, subject to some checks and verification with the 1975 County Special Census results. This information was not available at the traffic analysis zone level of detail during the time frame of this project.

The 1990 forecasts were used essentially as updated in 1974 during Phase One of the Rapid Transit Development Program study. The current 1990 forecasts used in RTDP Phase One and in this project represent a modest growth rate of only 2.3 percent annually. Over the next 15 years, this growth rate would amount to about a 37 percent increase in total County households and jobs, and result in about a 37 percent increase in total daily travel over today's. These projections for 1990 thus represent a fairly conservative growth rate, but one which is consistent with that experienced in this County over the last five years. The planning data is summarized in Table 1. Currently available information on trip making characteristics and regional and local development plans were also used.

Highway Network. The existing 1975 freeway, expressway and arterial highway system was assumed for both the 1975 and 1990 travel forecast years. In addition, the South Valley freeway (U.S. 101) was assumed to be completed for the year 1990, as well as numerous extensions, connections and widenings of the major arterial-thoroughfare system in new areas just developing. Key highway additions once planned for but not included in the highway network assumptions for this project are:

- Guadalupe Freeway - Route 87 between I-280 and Route 85

Table 1
DEMOGRAPHIC PLANNING DATA SUMMARY

	1975 Actual(1)	1975 Forecast(2)	1990 RTDP Forecast(3)
Total # Households	414,000	384,000	568,000
Total # Jobs	500,000	421,800	693,000
Total Population	1,169,000	1,295,000	1,580,000
Average HH Size	2.92	3.37	2.78

Note: Trip generation is based only on the first two demographic factors, total County households and jobs, and not on total population.

References:

1) 1975 Special County Census results, and 1975 California Department of Finance employment projections.

2) Santa Clara County Transportation Planning Study - Final Report. April 1969 by County Executive's Office.

3) Santa Clara County Rapid Transit Development Project - Phase One Summary Report. De Leuw, Cather & Company, December 1974.

- West Valley Freeway - Route 85 between Stevens Creek Boulevard and the South Valley Freeway.

- Widening of U.S. 101 to eight lanes between the San Mateo County line and the South Valley freeway near Cottle Road.

- Widening of I-280 to eight lanes between Magdalena Avenue and Highway 17.

Any changes in the above four key highway assumptions would have serious impacts on the transit ridership forecast figures presented in this report. The transitway ridership volumes are particularly sensitive to the level of highway congestion present on routes paralleling the transitway corridors.

Highway terminal times represent the time needed to walk to and park or unpark an automobile. At the home end, these times ranged between one and three minutes, while at the destination end they ranged from one to six minutes, the higher values representing the increased time needed in searching for and finding a parking space in congested activity centers.

Perceived auto operating costs were assumed to be 11 cents per mile, including gasoline costs at 60 cents per gallon. All parking in Santa Clara County was assumed to be provided free of charge.

Average automobile occupancy rates were assumed at the levels reported in the 1969 Transportation Planning Study (i.e., 1.17 for home-work trips and 1.44 for all trips).

This highway system was loaded using an incremental capacity restrained assignment of peak-period auto travel representing the AM peak-period levels of congestion for 1975 and 1990. The resulting decreased highway travel speeds and increased automobile travel times were used in forecasting the peak-period transit ridership in the five study corridors.

The unconstrained, free-flowing highway system was assumed for all non-peak period analyses.

Fare Levels and Fare Collection. Fare levels for the express transit service were set at the level needed to recover 30 percent of the total operating cost for providing the service, in accordance with the Transit District Board's direction. The local bus system's fares were assumed to remain at the 25-cent base fare levels. It was assumed that credit would be given for the transit fare previously paid when transferring from one County Transit vehicle to another. Thus local bus riders transferring to the transitway would only be required to pay the difference, if any, between the transitway fare and the local bus fare. Transitway riders would be permitted a free transfer to the local County buses. These fare rates and transfer privileges were also assumed to extend to Southern Pacific's Peninsula train service by virtue of an assumed agreement between the railroad and the Transit District. Initially, a fare of 25 cents per ride (1976 dollars) was assumed; fare levels and/or service levels were then modified as required as the analysis proceeded. Tests were made of ridership levels assuming a 35, 50, and 75-cent base fare. It was assumed that all fare collection would take place on-board the transit vehicles in the traditional manner, supplemented by additional personnel/facilities at heavy volume station/stops as needed.

Policy Toward Serving the Handicapped. The Transit District's stated policy toward the handicapped is to provide every new transit vehicle acquired with a wheelchair lift. This policy was assumed in this project, and all new transit vehicles required were costed with a $10,000 wheelchair lift. In addition, station/stops were assumed to be handicapped-accessible, either via a gently-sloping ramp if at-grade and an elevator if aerial.

Economic Analysis Assumptions. Benefit-Cost calculations were made as part of the cost-effectiveness evaluation. Benefits include the value of time saved, automobile operating cost avoided, the economic worth of reduction in highway accidents, parking costs avoided, and commercial vehicle savings. A discount rate of seven percent was used as a base case, with sensitivity tests made at four percent and ten percent. Consideration was also given to quantifying less traditional benefit items such as land use savings and reduction in water supply, sewer line, and auto ownership costs.

Transit efficiency measures were also calculated to supplement the benefit/cost analysis. Included were such items as capital and operating costs per passenger and per passenger mile.

Other Assumptions. Other assumptions discussed in Working Paper #1 related to details of: Southern Pacific Commuter Railroad characteristics, local county bus systems, collection-distribution characteristics, PUC safety regulations and standards, environmental impact factors, and economic cost factors.

THE ALTERNATIVES EVALUATION FRAMEWORK

Selection of a preferred transit alternative is a complex decision-making process which must not be over simplified. Recent experiences on similar projects elsewhere have shown that there are numerous tangible and intangible factors for both transit users and non-users which are relevant and need to be properly considered in reaching decisions on proposed improvements. Further, different -- and sometimes conflicting -- viewpoints and value judgements are involved. "Benefits" and "costs" can mean completely different things to the federal and local funding agencies, the system operator, system users, and non-users whose homes and businesses will be impacted by a proposed improvement.

Based on De Leuw, Cather's experience on similar projects elsewhere, it was felt that the following approach to a cost-effectiveness evaluation of alternatives is most appropriate for Santa Clara County. Briefly stated, this consists of:

- Defining both the various bus and light rail transit alternatives as completely as is reasonably possible.

- Estimating all the costs of each alternative.

- Describing the probable consequences, both transportation and non-transportation related, likely to be associated with the selection of each alternative using tables, photographs, maps, charts, working papers, or other material as most appropriate and as available resources permit.

- Arraying this material and presenting it in a systematic manner which facilitates the making of trade-off analyses by a variety of decision-makers with different value systems and priorities so that each can decide if differential consequences justify the differential costs.

Evaluation Criteria. Items which served as a means for comparing the various alternatives can be grouped under seven major areas:

1. Transportation Service Effectiveness

    - Number of peak hour and daily passengers served
    - Modal split
    - Access to selected activity centers
    - "Walk-in" population and employment
    - Service to transit dependents
    - Access by transit to employment opportunities

- Impact on freeway/expressway congestion levels
- Impact on parking space requirements

2. <u>Economic Feasibility</u>

   - Conventional cost evaluations
   - Conventional benefit factors
   - Other considerations--land use, infrastructure and automobile ownership savings

3. <u>Environmental Sensitivity</u>

   - Visual impact
   - Land use and urban growth
   - Joint development opportunities
   - Displacement of homes and jobs
   - Neighborhood intrusion or isolation
   - Air quality and energy impacts
   - Noise and vibration
   - Historical, cultural, and archeological sites
   - Community services
   - Parks and open space
   - Soils and geology
   - Ecological resources
   - Water resources

4. <u>Compatibility with Local, Regional and National Goals and Objectives</u>

   - Consistency with adopted local, regional, and state urban development plans, programs, and objectives
   - UMTA goals and objectives
   - National environmental objectives
   - Energy demands and balance-of-payments goals

5. Technological Suitability

- Safety
- Technical risk
- Flexibility and growth potential
- Procurement risk
- Service dependability

6. Community Acceptability and Political Support

- Transportation Commission
- Transit District Board
- Regional and local agencies
- Public at large

7 Financial Feasibility

- Local, State, and Federal funding sources
- Capital cost requirements
- Operating revenues, costs, and deficits

Each alternative and sub-alternative was measured on how well it succeeded in meeting the measures established within each of these seven evaluation areas. These findings are presented in Chapters IV through XII. An individual decision-maker may then place greater or lesser emphasis on each of these areas depending on his own sense of values and priorities. In this way, many decision-makers representing a wide cross-section of people and a diversity of opinion can all evaluate which transit alternative or alternatives are best suited for implementation in the five study corridors designated for this project.

CHAPTER II

CONCEPTUAL DEFINITION OF ALTERNATIVES

Before describing the alternatives tentatively selected for cost-effectiveness comparison in this study, it is necessary to discuss what is meant by an "alternative" in the context of this particular project. This study is concerned with the evaluation of alternative transit concepts in sufficient detail to provide a basis for informed discussions in regard to public policy. To accomplish this, it is necessary to examine only a reasonably representative example of the concepts to be considered. Thus, variations in alignment or profile, or differences in the number of stations or stops, which are quite important considerations at a preliminary engineering level, are not relevant "alternatives" at this initial planning level. Similarly, possible small differences in vehicle size or type of suspension are also not germane to the current study.

Alignment characteristics and hardware considerations are of concern only to the extent needed to ensure that a reasonable evaluation of the concept is made, that cost estimates are reliable, and that planning for the concepts does not grossly violate land use, urban planning and environmental or community requirements. System refinement and optimization of the selected concept can and should be deferred to a later date.

It is important to note that this study focuses on transit alternatives which can be incorporated into an early-action transit program. Such a program is particularly concerned with the next five to ten years. It is recognized that any major improvement must be justified when viewed from a longer-range perspective.

Five alternative transit concepts were identified for analysis and evaluation in this project:

1. Baseline Bus or "Do Nothing"

2. Increased Local Bus Service

3. Bus Preferential Treatment (TSM)

4. Busway Transit

5. Light Rail Transit

Development of each transit alternative included defining a viable transit network (alignment and station/stops), calculating the achievable average operating speeds, determining peak-period headways, assuming a fare policy, and defining realistic estimates of the access-egress modes and service levels which would be used to reach these transit lines.

Performance and operating characteristics of each transit alternative were presented in detail in Working Paper No. 1, "Functional Design Criteria", and are briefly described in the succeeding sections, with particular reference as to how each concept could be applied to meet Santa Clara County's transit needs.

ALTERNATIVE 1: BASELINE BUS TRANSIT

This alternative is designed to evaluate the consequences of not providing any significant transit service level improvements over and above those now being implemented. It provides a reference point or datum for measurement of costs and benefits against which the other transit alternatives can be compared. The baseline alternative is an assumed expansion

of present local bus service to 516 buses, operating on fixed routes on most major arterials offering significantly improved coverage and headways over those which exist today.

In addition to the basic "modified" grid arterial bus network, special bus services would also be offered -- expanded South County dial-a-ride services, more commuter bus pools, and several express bus routes running on freeways and expressways. The buspools and express routes would typically connect centers of residential areas with the larger employment and activity centers in the County.

Figure 2 shows the 25-seat Twin Coach bus now operated by the County Transit District. The new 516-bus expansion program calls for 300 new buses, including 255 35-foot buses, twenty 22- to 25-foot buses, and 25 large articulated buses.

The baseline transit system assumed for Santa Clara County in both forecast years consists of two major components: (1) the local county bus system, and (2) the Southern Pacific commuter railroad.

The baseline local bus system assumed for both the current and future levels of development is the adopted 516-bus system currently being implemented. This system, shown in Figure 3, consists of 46 bus routes covering the urban area of the County on the major arterial street system. Out of 46 routes, 25 will operate at 15-minute headways in peak periods and 21 at 30 minutes. Heavily traveled transit corridors such as El Camino Real/The Alameda and Foothill Expressway/Stevens Creek Boulevard/San Carlos Street will have buses scheduled every 7.5 minutes.

The District's bus routes and service levels were coded into a transit network using the County's 1990 highway network. All 46 bus routes were included in the baseline transit network. In order to get to and from a

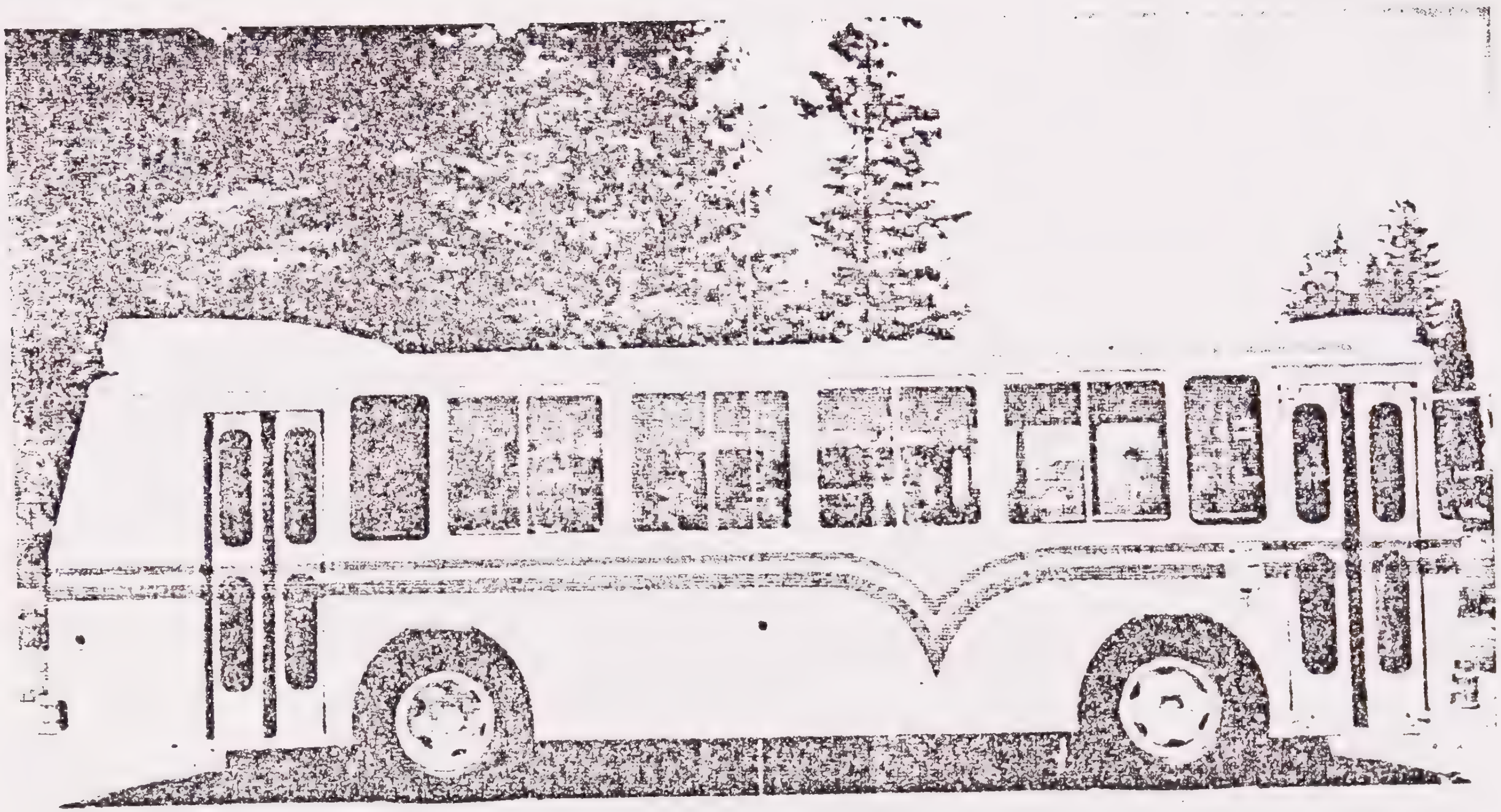


Figure 2
TWIN COACH BUS USED BY SCCTA

Figure 3
BASELINE/FEEDER BUS NETWORK
BASED ON COUNTY'S ADOPTED 516-BUS PLAN

bus stop, a walking speed of three miles per hour was assumed. The bus itself was assumed to average 10 miles per hour during peak periods, far below today's average of 14-15 miles per hour, due to heavy automobile congestion on most arterial streets in 1990. Transfer penalties were taken into account in a general way, assuming 25 percent of all bus riders would have to transfer and wait for another bus. Bus fares were assumed to be a flat 25 cents.

With minor modifications, this same local bus system was assumed to provide the necessary feeder bus collection-distribution-local (CDL) service to and from the transitway stations. This will be discussed more fully in the next sections.

Southern Pacific currently operates passenger train service daily between San Jose and San Francisco. Both service and fare rates are heavily oriented to serving the San Francisco commuter, who accounts for more that 80 percent of the system's 18,000 daily riders. Service and fares to intermediate points appear to be unattractive for all but a few students and workers. Nevertheless, the Southern Pacific line passes within one-to-two miles of about 25 percent of Santa Clara County's existing and forecast employment and the opportunity exists to serve many SC County home-work trip travel needs with this facility. One of the keys to unlocking this relatively untapped transit resource lies in improving service to intermediate stations, opening new stations in key locations, and in offering an attractive transfer to and from County transit vehicles in terms of both service and fares.

For purposes of this study, the current SP peak-hour headways were assumed, which is every 20 minutes for trains serving intermediate SC County stops. The SP trains were assumed to average 35 miles per hour within SC County, well within their current capabilities. In addition to the seven existing SP stations in the County, three new stations were assumed, located at San Tomas Expressway, Lawrence Expressway and San Antonio Road as shown in Figure 4.

De Leuw, Cather Company

Figure 4
SOUTHERN PACIFIC COMMUTER RAILROAD
IN SANTA CLARA COUNTY

ALTERNATIVES 2 and 3: LOW-CAPITAL-COST IMPROVED BUS SERVICE

Increasing emphasis is currently being placed on better use of existing transportation facilities by buses, especially on high-speed freeways and expressways. Use of such facilities by buses might offer a low capital-cost alternative to more expensive fixed-guidway/rail rapid transit solutions.

Buses have been using freeways and expressways for a number of years but with only partial success. When buses travel on freeways in mixed traffic with autos this impedes both their speed in areas of traffic congestion and their ability to make stops along the freeway to pick up and discharge passengers. Highways are capable of moving large numbers of people on buses through the design of special bus facilities and traffic control measures which can produce a high level of transit service. Fundamental to this objective, however, is the employment of bus priority facilities that include exclusive or preferential bus lanes and freeway on-ramps; traffic pre-emption controls for smooth, uninterrupted flow; special bus loading points and shelters; and park-and-ride lots.

"Transportation Systems Management (TSM)" is a required transit alternative which must be considered in accordance with the UMTA rules and regulations governing the conduct of Alternatives Analysis as promulgated in the September 17, 1975 Federal Register. This alternative is aimed at taking a serious look at what can be done with existing transportation facilites and resources to make them more efficient in terms of moving more people. It is concerned with low capital-cost measures such as bus preferential treatment, freeway ramp metering, priority treatment and special lanes for high occupancy vehicles, programs and incentives to encourage the formation and use of carpools, vanpools and buspools, staggered work hours, etc. UMTA requires that these low capital cost alternatives be seriously considered and compared with other, more capital-intensive alternatives such as transitways.

Two forms of low capital cost bus alternatives were examined during the course of this study - "Increased Local Bus Service" and "Bus Preferential Treatment (TSM)." The "Increased Local Bus Service" alternative increased the number and/or type of buses and assumed lower capital cost improvements in bus operations such as express bus services and preferential bus treatment on downtown streets. The second alternative, "Bus Preferential Treatment (TSM)", considered somewhat higher capital cost improvements such as reserved bus lanes, traffic signal pre-emption, park-and-ride lots, and other measures which could have a more significant impact on automobile traffic.

Increased Local Bus Service Alternative

The Increased Local Bus Service alternative developed for patronage testing involved a doubling of the service level which would be provided by the Baseline Bus system now in the process of being implemented. Instead of an average Countywide peak-period bus headway of 20 minutes afforded by the 516-bus system on 46 routes, this alternative would cut the average headway to 10 minutes. Bus headways on heavily patronized routes such as El Camino Real/The Alameda, Foothill Expressway/Stevens Creek/San Carlos Street, Almaden Expressway/Lincoln Avenue and Monterey Highway/First Street would have peak-period headways in the three to four minute range under this alternative. This option would represent a very good local bus system with a high level of service. In order to provide this service, however, an approximate doubling of the presently planned 516-bus fleet would be required.

Current Santa Clara County TSM Plans

The Santa Clara County Transit District is now embarked on a $65 million bus expansion and service improvement program which when completed will add a number of new transit services throughout the County and should significantly boost transit ridership. As part of this bus improvement program, the Santa Clara Transportation Agency (SCCTA) is planning on instituting a variety of Transportation Systems Management (TSM) measures including peak-hour express bus services using freeways, expressways, and park-and-ride lots; the installation of high occupancy lanes; the installation of systems for bus pre-emption of traffic signals; and the installation of bus activated signals at congested and unsafe locations. The objective is to increase the effectiveness of the local arterial road system by encouraging higher occupancy uses of private automobiles and transit buses. In addition, Caltrans, the agency responsible for the area's freeway construction and operations, is undertaking a major program to ramp- meter all of the urban area's congested freeways by 1980.

The County's TSM plan now being implemented consists of the following elements:

- Implementation of reserved lanes for high occupany vehicles.
- Installation of bus priority signalization at major points of congestion and safety need.
- Institution of ramp-metering of the area's congested freeways.

The SCCTA has proposed the designation of one lane in each direction on the Almaden Expressway as an exclusive high occupany lane for buses and car pools. The installation of these exclusive lanes between Redmond Road and Lincoln Avenue will complement the near-term installation of a system for the pre-emption of Almaden Expressway traffic signals by CTD buses.

Specifically, two outside lanes on the 3.9 mile segment of Almaden Expressway between Redmond Road and Lincoln Avenue, one in each direction, would be designated for use by car pools and buses only during the peak hours.

The high occupancy lane designation on Almaden Expressway requires the concurrance and cooperation of the City of San Jose. The future of this endeavor lies in a solution to the police enforcement of the exclusive lanes. Due to budget constraints, additional police enforcement of the special lanes cannot be made available without reimbursement to the police agency. A search for a funding source to provide policing for a one year normalization period has been undertaken. One prospective source of funding assistance is Section 9 of S.B. 283, for which application is being made. If a law enforcement arrangement could be achieved and agreement with the City of San Jose reached, the special lanes could be fully operational in early 1977, following the completion of the current widening of Almaden Expressway from four to six lanes.

The SCCTA is also proposing to implement high occupancy lanes the full length of San Tomas Expressway from Highway 17 to Highway 101. These exclusive lanes, one in each direction during the peak commute hours, would be used exclusively by carpooling and van pooling vehicles. This project is to be coordinated with ramp metering installations by Caltrans on Highway 17 and Highway 101.

San Tomas Expressway has been recently improved from four to six lanes between El Camino Real and Highway 101, with noise walls and landscaping. The remaining portion of San Tomas from El Camino Real to Highway 17 is programmed for staged improvements, including soundwalls, landscaping, and the addition of one travel lane in each direction.

On Capitol Expressway between Almaden Expressway and Highway 101, the Transportation Agency is again proposing to implement high occupancy lanes. One lane in each direction during the peak commute hours would be exclusively used by carpooling and vanpooling vehicles.

The implementation of these lanes is contingent upon the resolution of the issues previously mentioned, the operational experiences on Almaden Expressway, and also the resulting degree of success.

Bus Priority Signalization

As a part of Transportation Agency's program for the utilization of priority techniques for high occupancy vehicles, the concept of special priority signalization at congested and unsafe locations is being pursued.

These priority signals would serve the following objectives:

1. Reduce delays in the schedule and increase the safety of the bus operation, both of which should reduce operating costs.

2. Increase ridership by the upgrading of service in terms of centralized stops and convenient transfers.

There will be some negative impact on auto users due to added delays at the transit signals. Overall, however, the positive gain to transit should outweigh this impact and there would be an increase in the total carrying capacity of the roadway.

One of the underlying objectives of priority signalization is to get the transit user closer to his destination and to bring the buses together at a common stop for easy transferring. To achieve this objective, the route will often have to leave the main street and enter a shopping center, hospital, school, or other major activity center where a common, centralized stop can be located. With heavy auto traffic on many major arterials, this turning movement is often hazardous and very time consuming. Whenever possible, existing signalized intersections are used. However, quite often these are not properly located to serve the requirements of a fixed transit route. Therefore, there are many locations where the desired objective cannot be achieved without the installation of a special signal designed to allow a turning movement for transit vehicles only.

Ramp Metering of Congested Freeways

The following freeway locations have been proposed for installation of ramp meters to control traffic entry to the freeway at volume levels necessary to keep auto speeds up and prevent a jamming situation. Some of the projects have already been budgeted while others are awaiting approval in the current planning program for CalTrans. All are expected to be in place and working in the next two or three years.

- Highway 17-Los Gatos to U.S. 101 Interchange
- U.S. 101-Bayshore-Highway 17 to San Mateo County Line

- U.S. 101-Highway 17 to Capitol Expressway
- I-280 Winchester to Stevens Freeway-Route 85

Bus Preferential Treatment (TSM) Alternative

The Bus Preferential Treatment (TSM) alternative also assumed the expansion of the present 236-bus service to the level and deployment as shown in the proposed County Transit District Plan of November 1975. Existing and planned bus routes paralleling the five designated study corridors were examined for the possibility and advantage of bus preferential treatments. An inventory of those major highway facilities which might prove capable of permitting frequent and high-speed bus operations in the five study corridors was undertaken. In addition, an analysis was made to determine where the high-speed, high-volume transit potential might be oriented in these corridors, and to explore the existing and projected highway congestion levels which would impact bus travel speeds in these five corridors. As a result of this search, the following criteria were used to select roadway facilities capable of providing high-speed bus operations with priority treatments:

- Presence of a heavy peak-period transit demand potential which would require 20 or more conventional 45-seat buses.
- Severely congested peak-period travel condition which would slow bus operations to below 15 miles per hour.
- Presence of a six-to-eight-lane freeway serving the corridor which is planned to be ramp metered, and which would permit the installation of bus priority entry ramps at key interchanges.
- Presence of a six to eight lane expressway or major arterial street which would permit the installation of transit signal pre-emptions at traffic intersections and reserved bus lanes (either normal-flow or contra-flow).

Figure 5
BUS PREFERENTIAL TREATMENT NETWORK

Bus priority measures considered included special contra-flow bus (and carpool) lanes on parallel expressways and arterial streets (Almaden Expressway, Bascom Avenue, and Prospect/Hamilton Avenues), ramp metering with special bus priority entry ramps (Highway 17 and I-280), reserved bus lanes on arterial streets (Blossom Hill Road and Monterey Highway), and bus priority by signal pre-emption devices.

A number of possible express routes were tested along these streets and highways to see if the ridership demand would create enough bus volumes or benefits to justify implementing bus preferential treatment measures. The result was a priority bus network serving the five study corridors consisting of about 40 miles of expressway/arterial reserved bus lanes with signal pre-emption on which it was assumed buses could average 20 miles per hour during peak travel periods in 1990, and about eight miles of metered freeways with bus priority entry ramps permitting 30 mile-per-hour average bus speeds. This selected bus priority network is shown in Figure 5.

ALTERNATIVE 4: BUSWAY TRANSIT

The busway alternative is a higher capital cost/lower operating cost transit alternative aimed at increasing bus operating speeds and driver productivity. To accomplish this, high speed bus roadways would be constructed at grade inasmuch as is physically possible and segregated from interference from other traffic such as is shown in Figure 6. Grade separations over major obstacles such as freeways, expressways, and stream channels will be required. Other grade separations with major arterial streets may prove to be both operationally desirable and cost-effective. The purchase and operation of large articulated "superbuses" such as is shown in Figure 7 were assumed for operation on the busway. Busway operations may also be combined with some or all of the bus preferential treatment measures outlined in the previous alternative.

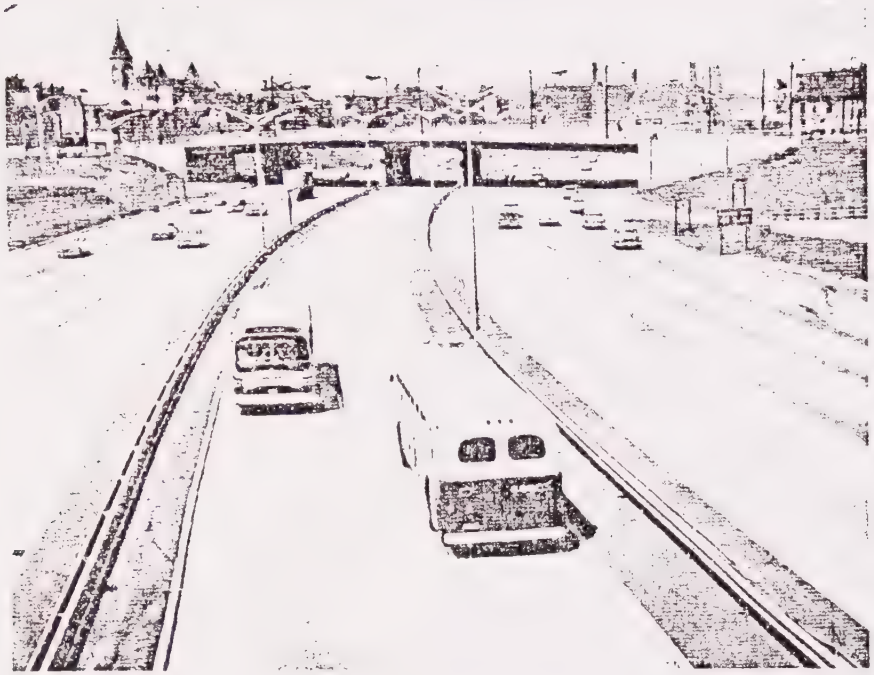


Figure 6
BUSWAY CONSTRUCTED IN FREEWAY MEDIAN

Figure 7
M.A.N. LARGE ARTICULATED DIESEL BUS

Since buses are manually steered, rubber-tired vehicles with no restriction to a fixed track or power source, they are able to operate on local and arterial streets in a conventional manner, picking up and dropping off passengers in a collection and distribution mode without the necessity to transfer to another vehicle, such as is the case with most fixed-rail systems. Busways which feature buses operating in a collection mode on local streets, entering an exclusive busway, and then proceeding downstream and getting off the busway to distribute their passengers on local streets again are termed "open busways." Busways which feature buses operating solely on the busway and relying on passenger access by transfer from feeder buses or auto park-and-ride lots at stations are termed "closed busways." Most busways built to date offer a combination of the two types of systems.

Busways can require station/stop facilities, including parking lots, passenger shelters, fare collection equipment and bus loading berths and platforms. If the buses can successfully gather passenger loads by circulating on local streets prior to entering the busway, the size and need for bus station/stop facilities may be greatly reduced. However, in an area of such low density and diverse travel patterns as Santa Clara County, where there is no large central employment area, it is difficult to gather a bus load of riders within a small residential area, all with the same general destination at the same general time of day. Therefore, successful express bus operations dictate that riders first collect at various points along the busway (station/stops) and then transfer to the express bus line which will take them closest to their final destination.

The five study corridors were examined to determine the feasibility of constructing new special bus roadways in them, which would be built at

grade for the most part. The relative advantages and disadvantages of providing grade separations or signal pre-emptions at intersections with cross streets were examined. Both "open" and "closed" types of bus operations were considered, as well as the choice between a downtown terminal and transfer to a local shuttle bus or a direct downtown bus distribution loop. The expanded 516-bus fleet was assumed as providing an adequate local and feeder bus service connecting with each of the busway stations. Appropriate modifications would be made within the five study corridors to avoid duplication of parallel bus services.

The Busway Alternative developed for patronage testing is shown in Figure 8 and consists of some 34 miles of two-way bus lanes constructed principally at-grade with signal pre-emption and some 40 station/stops. Nearing downtown San Jose, the busway would terminate at the Southern Pacific Depot where a cross-platform transfer facility would facilitate quick and convenient transfers to waiting SP trains. From here, buses could continue through the CBD core and to the Civic Center area using reserved lanes on local streets. Large, 60-foot articulated buses capable of achieving 60 mph top speeds would be used on the busway in order to gain operating economies.

Access and egress to the busway station/stops was assumed to be by a combination of walking, local CDL service and private automobile "kiss-and-ride" and "park-and-ride". This assumption is discussed in more detail in the next section describing the light rail transit system alternative. Bus headways were assumed to require an average waiting time of four minutes throughout the system.

Figure 8
FIVE-CORRIDOR TRANSITWAY NETWORK
+ SPRR USED IN PATRONAGE FORECASTING

A flat-fare of 25 cents was assumed in the "Base Case" Busway patronage forecast as a first estimate of the fare level needed to recover 30 percent of the busway's operating costs. Sensitivity tests were run at higher fare levels in case this 25 cents flat-fare level should turn out to be insufficient to recover 30 percent of the busway's operating costs. Free transfers were assumed between local District buses at both ends of the busway ride and to the Southern Pacific trains serving trips within Santa Clara County.

Upon reviewing the required headways between buses (assumed to be all articulated, 105-person carrying capacity) in order to handle the forecast 1990 travel demands, it was noted that bus headways under two minutes would be required on the Guadalupe/Monterey Highway corridor, and under three minutes on the Vasona/Winchester Boulevard corridor. Assuming busway operations in both directions during peak periods, the bus crossing frequencies at the at-grade intersections on these corridors would fall below 1-1/2 minutes, or below the traffic signal cycle lengths currently in effect at most of these intersections.

Transit pre-emption of traffic signals would not be 100 percent guaranteed. As the headway between transit vehicles decreased, so would the chances of obtaining a "through" green light. When bus headways become smaller than the traffic signal cycle lengths, buses will be forced to stop at some intersections and will begin queuing up in twos and threes. Assuming an all-stop, on-line mode of busway operation, congestion and delays could begin occurring at station/stops when bus headways fall under two minutes (one minute in each direction). All of these delays and signal waits would result in a degradation of the average operating speed of the busway from about 30 mph to 25 mph (an extra three to four minutes of travel time within a seven-mile transitway ride). Thus the lower average speed figures were assumed throughout for the "Base Case" busway as shown in Figure 9, "Transitway Average Operating Speeds Assumed."

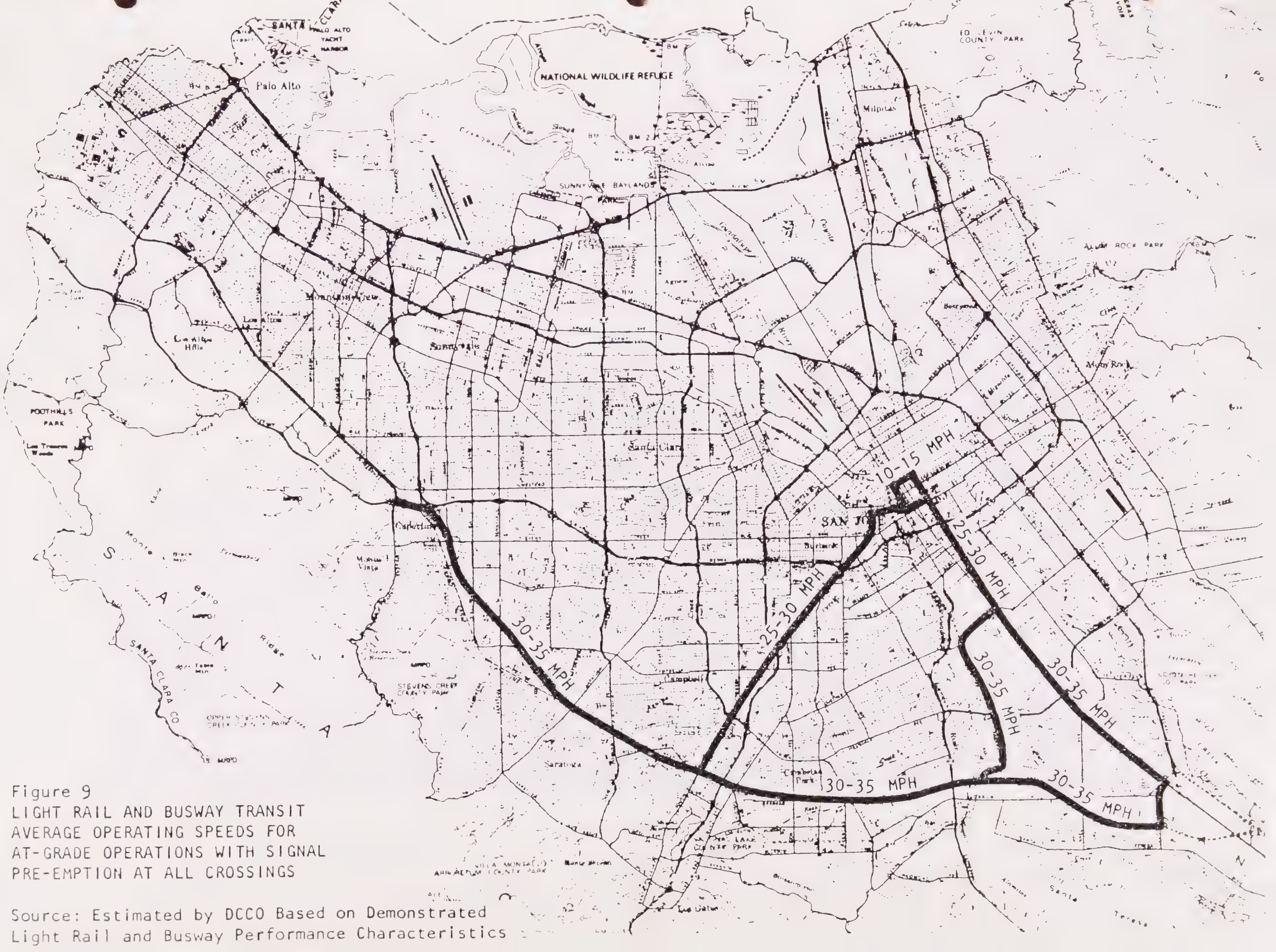


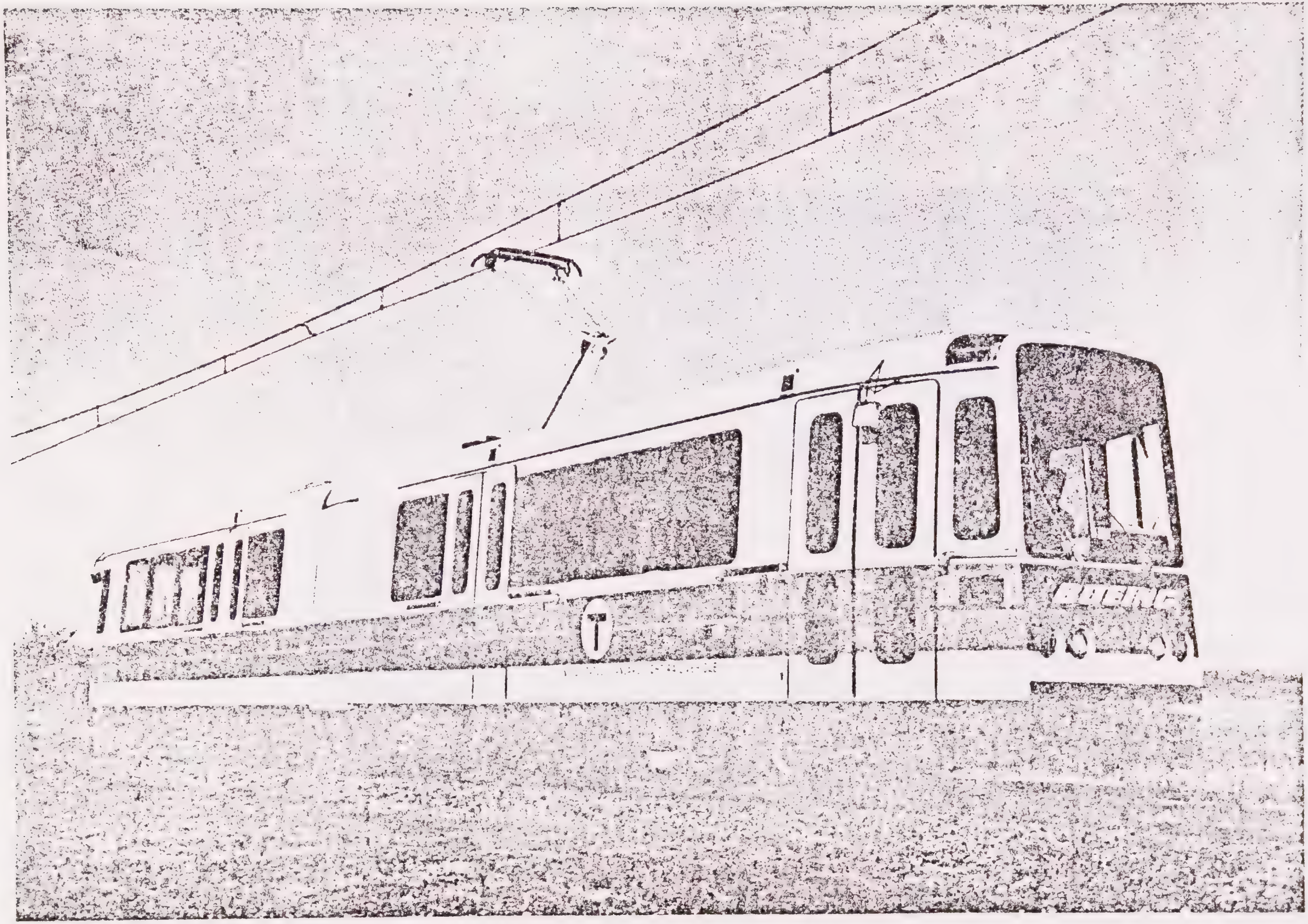
Figure 9
LIGHT RAIL AND BUSWAY TRANSIT AVERAGE OPERATING SPEEDS FOR AT-GRADE OPERATIONS WITH SIGNAL PRE-EMPTION AT ALL CROSSINGS

Source: Estimated by DCCO Based on Demonstrated Light Rail and Busway Performance Characteristics

ALTERNATIVE 5: LIGHT RAIL TRANSIT

The Light Rail Transit (LRT) alternative, also sometimes referred to as "Pre-Metro" or "Semi-Metro," features an electrically propelled, medium capacity, steel-wheel, steel-rail vehicle capable of operating either as a single unit or in multi-unit trains on both exclusive rights-of-way and at-grade within existing streets. The term "Pre-Metro" refers to the European practice of utilizing this mode as an intermediate stage leading eventually to a fully grade-separated, high capacity "Metro," or conventional rail rapid transit system. At the other extreme, a light rail system has operating characteristics very similar to that of a conventional bus system or streetcar. The difference between these extremes depends on the amount of exclusive, grade-separated right-of-way incorporated in the system's design.

Light rail transit systems have historically evolved from surface street railway (streetcar) systems. Today's modern "light rail" system usually consists of 50 to 80-seat vehicles such as the one shown in Figure 10, operating singly or in trains on standard-gauge steel rails located within street or railroad rights-of-way. They are powered by overhead trolley wires which feed electric motors under the car body. Historically, streetcars ran on surface-level tracks with or without reserved rights-of-way and at speeds generally averaging 10 to 20 MPH. During the past two decades, while most American cities were phasing out the last of their streetcar systems, many European cities were systematically up-grading, modernizing, and undergrounding their light rail systems. Some of these European systems, most notably those in West Germany, have travel speeds as high as 25 to 30 MPH, a line-haul capacity of up to 15,000 persons per hour, high reliability and other features similar to those of heavy rail rapid transit. This high quality of service has been achieved mainly through the provision of reserved rights-of-way, partially or fully grade-separated from automobile traffic, and the construction of modern light rail vehicles (see Figures 11 and 12).



U.S. STANDARD LIGHT RAIL VEHICLE DEVELOPED BY BOEING VERTOL

Figure 11
LIGHT RAIL TRANSIT RUNNING IN RESERVED TRANSIT LANE ON ARTERIAL STREET, ZURICH

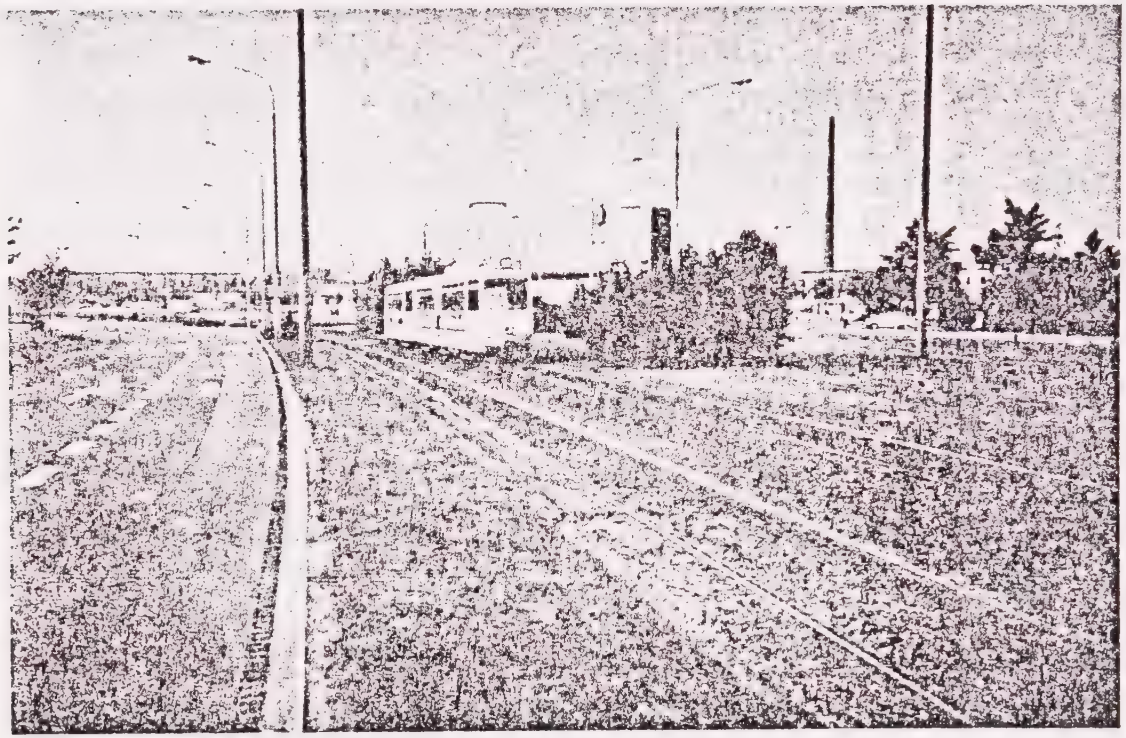


Figure 12
LIGHT RAIL TRANSIT RUNNING IN LANDSCAPED MEDIAN
OF AN EXPRESSWAY, BRAUNSCHWEIG

Since light rail can have at-grade crossings and even sections of shared rights-of-way, it may be considerably easier to find suitable rights-of-way for it than for full Metro rapid transit. Light rail transit may be introduced on many sections of lightly used or abandoned railroad rights-of-way since performance requirements are less stringent. The dedication of existing street lanes may be another low-cost approach. Utility rights-of-way, road median strips, linear parks, etc., offer other possible low cost right-of-way opportunities.

In Santa Clara County, the design objective would be to retain as much of the economic advantage of this mode as possible by employing at-grade operation wherever feasible while maximizing the performance characteristics of light rail in order to provide a highly attractive and competitive transit service. This will require the use of such features as reserved pedestrian/transit mall areas, channelization and protection from crossing and turning automobile traffic, elimination of interference from automobiles, pedestrian movements and other traffic insofar as is possible, as well as high transit operating speeds, service frequencies and other characteristics of service levels. The relative costs and benefits of providing increasing levels of grade separations, thereby increasing speed and reliability, were explored.

Light rail transit vehicles can be coupled together to form small trains, if required, and would operate on a protected right-of-way segregated from other traffic as much as proves cost effective. Grade separations over major obstacles such as freeways, expressways and stream channels will be required. Other grade separations with major arterial streets may prove to be desirable to maintain a high performance level.

The Light Rail Transit network developed for patronage testing as the "Base Case" is the same as the Busway network shown in Figure 8 and consists of 34 miles of double-track line constructed principally

at-grade with signal pre-emption and some 40 station/stops. Nearing downtown San Jose, the light rail system would pass through the SP Depot area where a cross-platform transfer facility would enable quick and convenient transfers to waiting SP trains. From here, the options are to continue the light rail tracks through the CBD core in reserved transit right-of-way on local streets (requires reconstructing the roadways), or to terminate at the SP Depot and provide frequent shuttle bus service to the CBD and Civic Center areas.

Providing access to the light rail network and also complementing it would be an expanded bus system deployed in a similar fashion to that shown in the County Transit District (CTD) plan of November 1975. Appropriate modifications to this bus network would be made to provide direct service to the LRT stations and to eliminate any parallel duplication of express bus routes. Provisions were made for auto access transfer facilities by providing park-and-ride lots at station sites. Access to the transitway station/stops was assumed to be by a combination of modes consisting of walking at three mph, local bus at 10 mph (average 5-minute walk to bus and 10-minute wait for bus) and private automobile at 18 mph (1.0 persons/auto assumed; a 4 minute auto park-and-ride terminal time was also assumed). Perceived automobile operating costs were assumed to be 11 cents per vehicle-mile. Parking was assumed to be free everywhere throughout the County.

The light rail vehicle chosen for operations was assumed to be comparable to the 71-foot articulated U.S. standard LRV now being built by Boeing for Boston and San Francisco shown in Figure 10. The LRV is assumed to be capable of a top speed of 60 mph and a carrying capacity at crush load of 219 passengers.

Severely congested cross streets were assumed to be grade-separated and all of the remaining cross streets pre-empted in favor of passing transit vehicles. Figure 9 shows the calculated light rail average operating speeds of 25-30 mph including 10-second station/stop dwell times. Average line headways were assumed at eight minutes, resulting in an average waiting time of four minutes.

Fare levels were set so as to recover 30 percent of the transitway's operating costs. Preliminary analysis showed this to be between 25 cents and 35 cents, depending on fare discounts offered, final operating costs and actual ridership levels achieved (San Francisco's Muni streetcar system recovers about 40 percent from its farebox with a 25-cent fare today). A constant flat fare of 25 cents was assumed for all local bus trips. Payment of this initial 25 cents transit fare was assumed credited toward any transitway fare.

It was assumed that the Transit District would permit users traveling wholly within SC County to ride Southern Pacific's trains at the prevailing fare rate charged on the transitway, with free transfers between the transitway and the railroad. Local bus transfers to SP would cost only the difference in the two fare structures, i.e., credit would be given for the 25-cent bus fare already paid, while transfers from SP to local buses would be free. Average headway on SP's Peninsula service was assumed to require an additional ten-minute waiting time for transferring passengers. SP trains were assumed to average 35 mph.

CHAPTER III

FUNCTIONAL DESIGN CRITERIA AND ALIGNMENT REVIEW

Each of the alternaitve transit concepts can be represented by a set of design criteria and performance characteristics and these can be found in greater detail in Chapter III of Working Paper No. One. Design criteria includes information needed for plan and profile alignment studies, cost estimates and impact studies. They include vehicle characteristics, geometric standards, prototypical line crossections and station or stop layouts. Performance characteristics include operating patterns, maximum speeds, station or stop dwell times, minimum and policy headways, loading standards and similar information needed as inputs to the patronage analysis and for the preparation of operating cost estimates. A summary of the major design criteria and performance characteristics utilized in this study follows.

VEHICLES

Both the light rail and the bus system alternatives have existing, off the shelf, vehicle models to base design criteria on. Either system can be purchased with improved features, such as more attractive interiors, comfortable seats, air conditioning, wider vehicles, etc.

The bus concept offers a wide range of vehicle types, from small 20-foot buses to the conventional 40-foot bus, to a double-decker superbus or a 60-foot articulated bus. It can run with a standard diesel or propane engine or an electric motor powered from overhead trolley wires. For purposes of this analysis, however, the comparison will be limited to only four types, i.e., conventional buses and articulated buses powered by diesel engines.

The light rail concept also offers a variety of vehicle types. They are available over a large range of capacities ranging in length from 26 feet to 97 feet and seating from 30 to 100 passengers. They can also offer the two propulsion options of electric traction motors or diesel engines. For purposes of this alternatives analysis, a prototypical vehicle 71 feet long with a seating capacity of 68 passengers and electric traction motors powered by an overhead catenary system will be used. The Boeing company is designing such a vehicle for use in Boston and San Francisco. It may be run as a single car or coupled in trains of up to four cars. The height of the overhead power pickup wire can presently vary between a minimum of approximately 12 feet-6 inches to a maximum of 19 feet. If the system is to cross railroad spur tracks at grade, some modification to the pantograph will be required in order to raise the maximum wire height to at least 23 feet as required for railroad crossings.

Table 2 offers a comparison of the design criteria associated with these vehicle types.

GEOMETRICS

Guideway maximum horizontal curvature is governed by three things: the amount of superelevation applied through the curve, the amount of unbalance allowed, and the design speed. The standard maximum amount of superelevation cross-slope used for both railways and roadways is about 10 percent. For a 4 feet 8-1/2 inch standard gauge railway, this amounts to about six inches. The amount of unbalance allowed when standees are present is usually limited by passenger comfort levels and not by vehicle restrictions or friction limits. Therefore, for any given design speed, the maximum horizontal curvature will be the same for either light rail or buses. The only real difference may be that light rail trackwork will require the use of definite transition spirals in final design, while the bus roadway may not.

Table 2

VEHICLE DESIGN CRITERIA

	Light Rail	Conventional Bus	Articulated Bus
Vehicle Dimensions			
Length (ft)	72	40	60
Width (ft)	9	8 1/2	8 1/2
Height (ft)	12 1/2	10 1/2	10 1/2
Capacity			
Seated	68	45	70
Standees	100	25	35
Crush Load	219	90	140
Weight empty (lb)	69,000	20,000	30,000
Max. Operating Speeds (MPH)	60	60	60
Deceleration Rates			
Normal (ft/sec^2) (w/Standees)	4	4	4
Emergency (ft/sec^2)	9	10	10

Vertical curvature requirements also show little or no difference for the two systems. Unless you have a fully grade separated and protected guideway (such as BART), crest curves must be governed by safe stopping sight distance. The minumum length for a vertical curve based on safe stopping sight distance is governed by three things: the height of the driver above the travel surface, the height of the object to be avoided, and the deceleration rates of the vehicle. For both the bus and the light rail vehicle, the driver is approximately the same height above the travel-way, approximately five feet. Also, the normal and maximum rates of deceleration for buses and light rail with standees are the same. Therefore, the length of the crest vertical curves should be identical for either system.

Sag curves can be designed for safe stopping sight distances or comfort. In a lighted area, the comfort criteria will govern the minimum length of curve, while in an unlighted area, the headlight stopping sight distance will govern. As with the crest curve, stopping sight distance based on headlight control should be the same for either system. Since both a busway and a light rail line can be lighted, a design based on comfort should be used. There could be a slight difference between the vehicle suspension system, but this should not make a significant difference in the length of the sag curve.

There are some differences between bus and light rail absolute minimum operating criteria. A bus can negotiate a sharper minimum radius and a bus can climb a steeper maximum grade, but it was found not necessary to use these extreme limits anywhere is this study.

GUIDEWAYS

The main differences between the guideway requirements for a busway or a light rail track are due to the wider cross section needed for a busway. In an extremely tight right-of-way situation, a light rail system

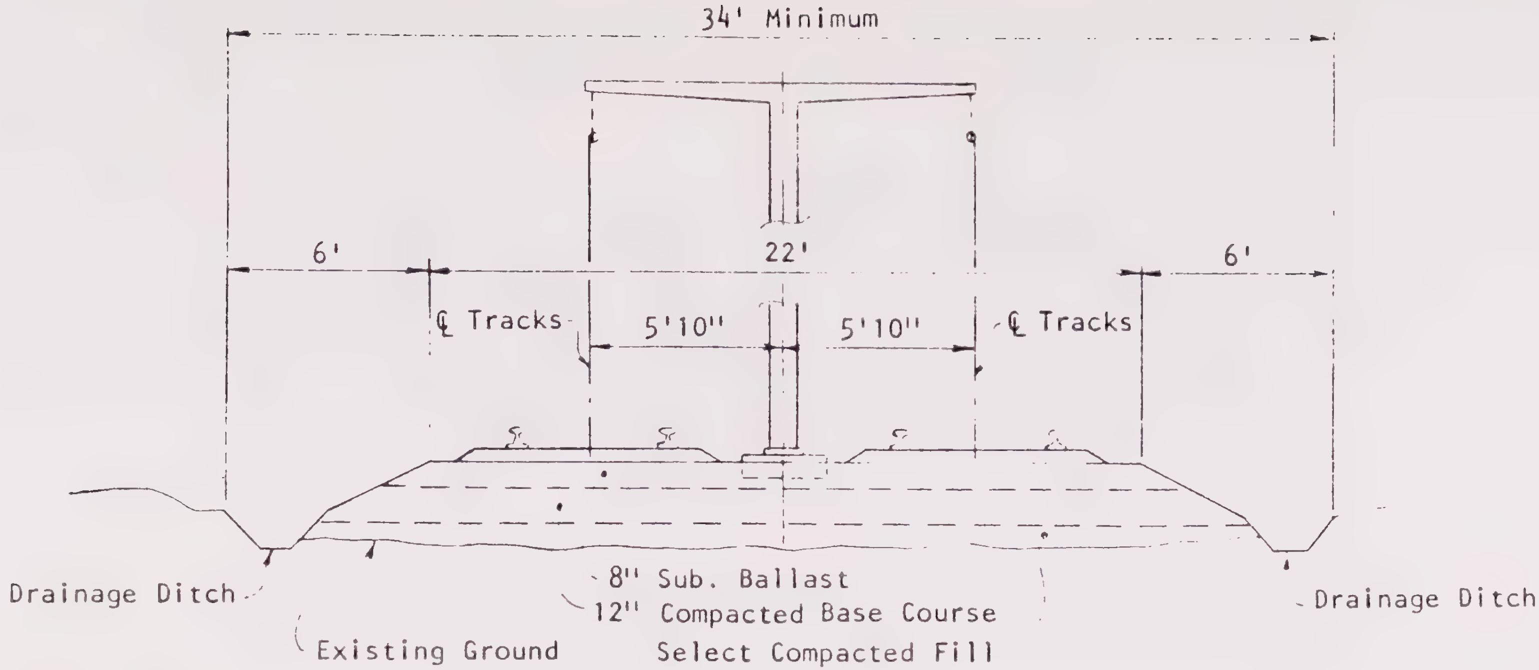
can be placed in a 23-foot wide section, whereas a busway usually requires a minimum 34-foot section. For a short distance a busway could be reduced to a 26-foot section without shoulders, but this would not be desirable for any distance. These minimums apply to both aerial and at-grade alignments. See Figures 13 to 15.

For both the bus and the light rail alternatives, it is assumed for the purposes of this study that at-grade crossings will be permitted at most arterial street intersections. At these locations it is assumed that traffic signals will be provided and railroad crossing gates would be used as supplementary control. Traffic signal pre-emption by the transit vehicle will be used wherever the traffic volumes on the cross streets are able to accomodate the transit frequencies. In situations where traffic on a local cross street is such that transit vehicle pre-emption would result in a significant detèrioration of traffic service, traffic signals would not be pre-empted and guideway grade separations have been proposed.

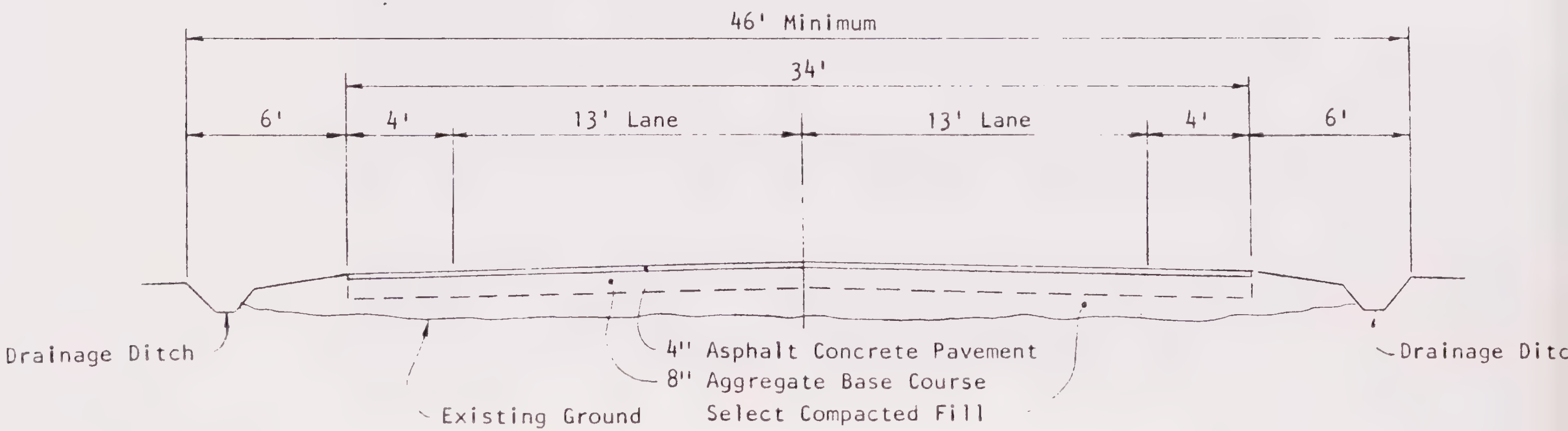
The Bus Preferential Treatment (TSM) alternative utilized, among other elements, priority bus lanes and freeway on ramp by-passes. Some typical design arrangements of these facilities are shown in Figures 16 and 17.

STATIONS

For both the light rail system and the bus system alternatives, a minimum station shelter and platform design is being assumed. A low-level platform length of 80 feet was assumed, which would accommodate one light rail vehicle or articulated bus or two conventional buses. At a later date, as patronage increased, these stations could be increased in length. The alignment is such that extensions of platform lengths could be accommodated. It is assumed that a County Transit District standard transit shelter will be installed at each station/stop location.

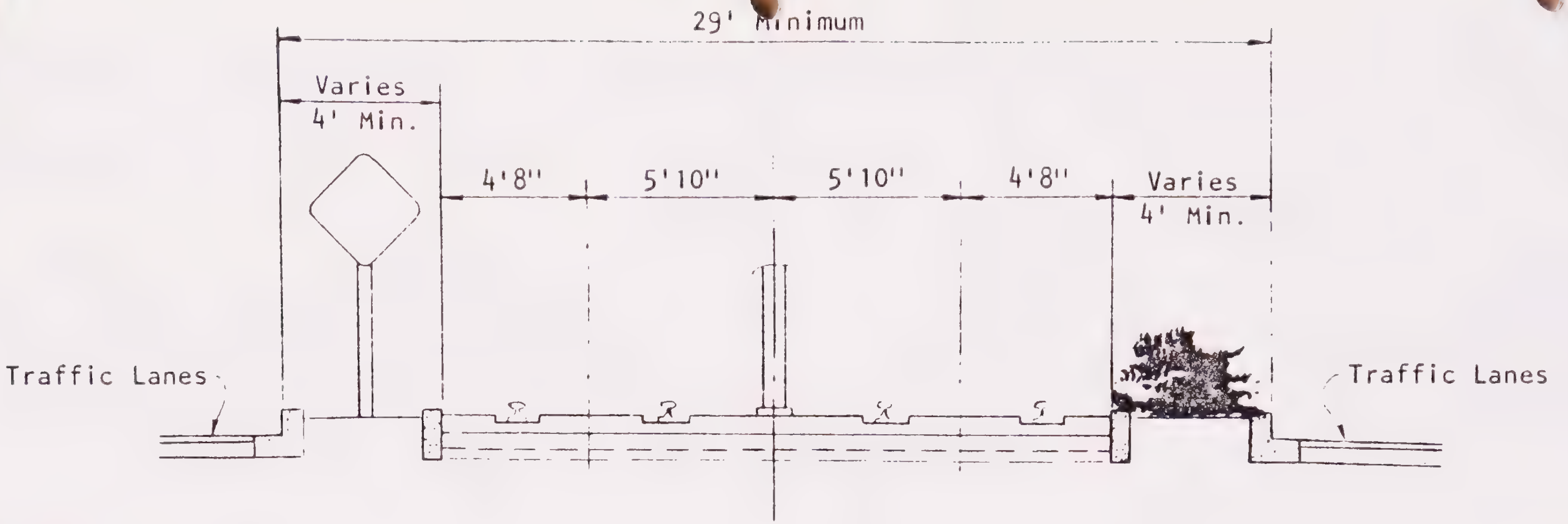


LIGHT RAIL



BUSWAY

Figure 13
TYPICAL AT-GRADE GUIDEWAY SECTIONS (:PARATE R/W)



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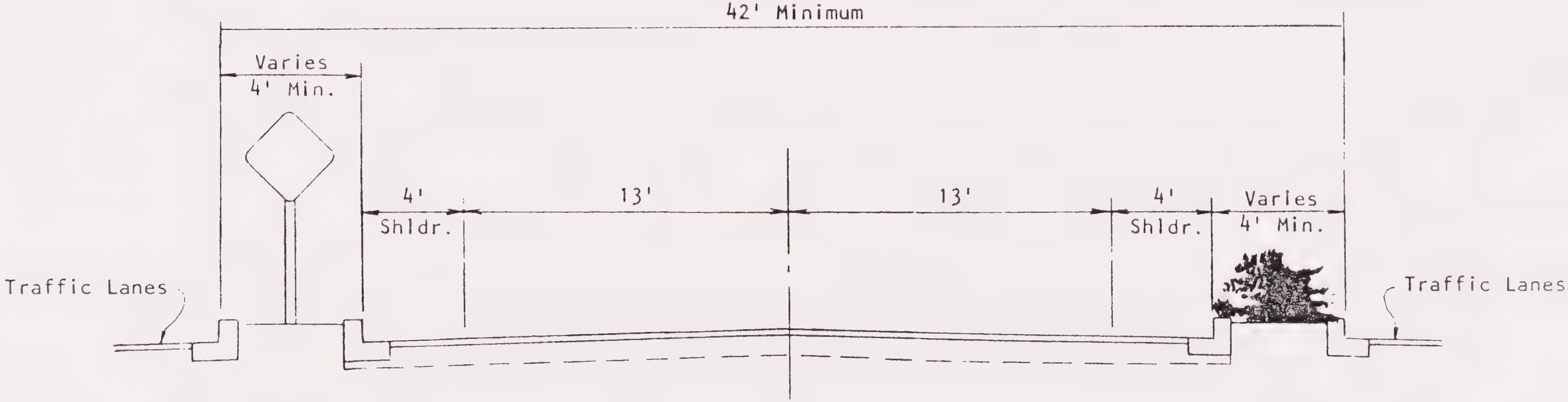
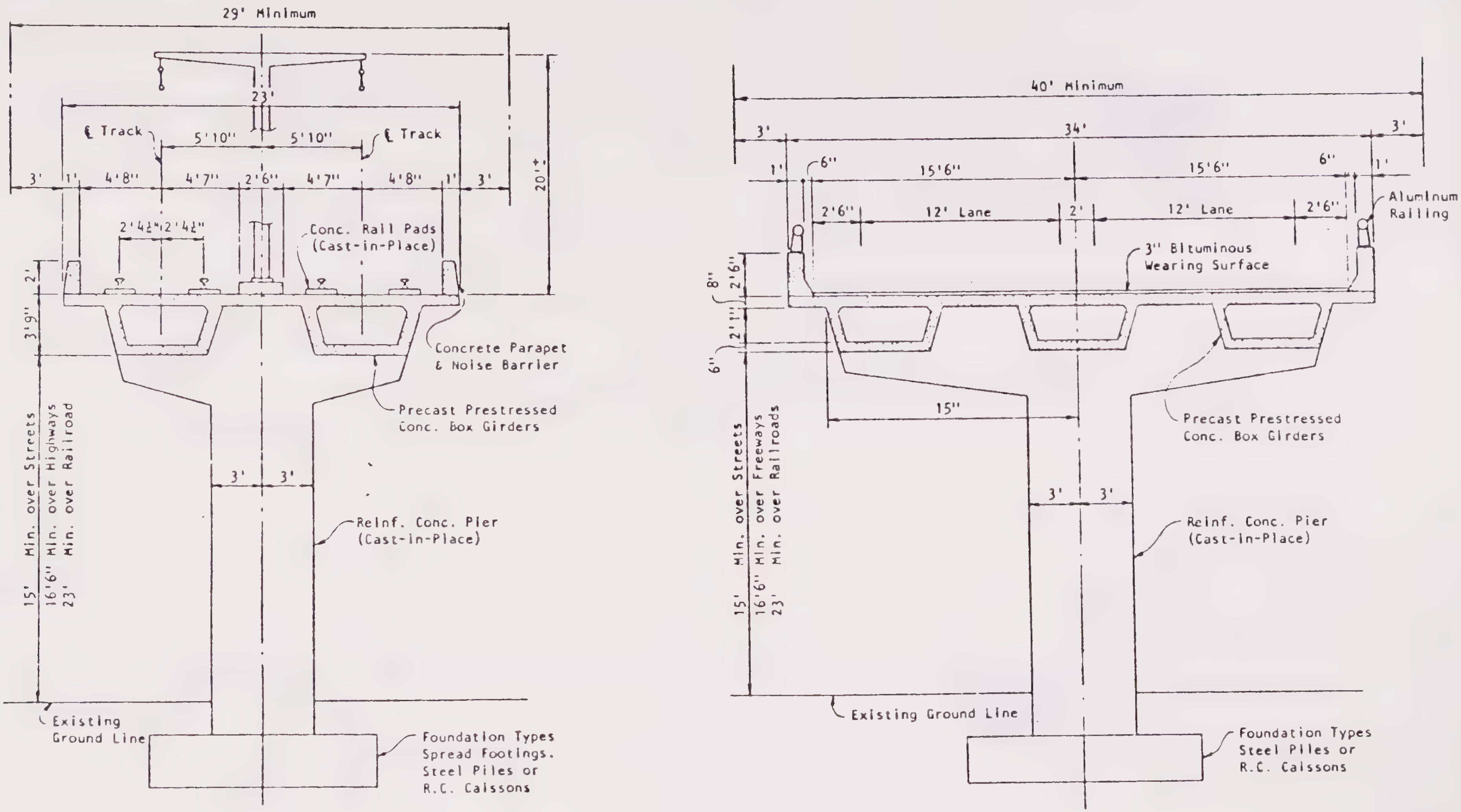


BUSWAY

Figure 14
TYPICAL AT-GRADE GUIDEWAY SECTIONS (MEDIAN OF ARTERIAL R/W)



LIGHT RAIL

BUSWAY

Figure 15
TYPICAL AERIAL GUIDEWAY SECTIONS

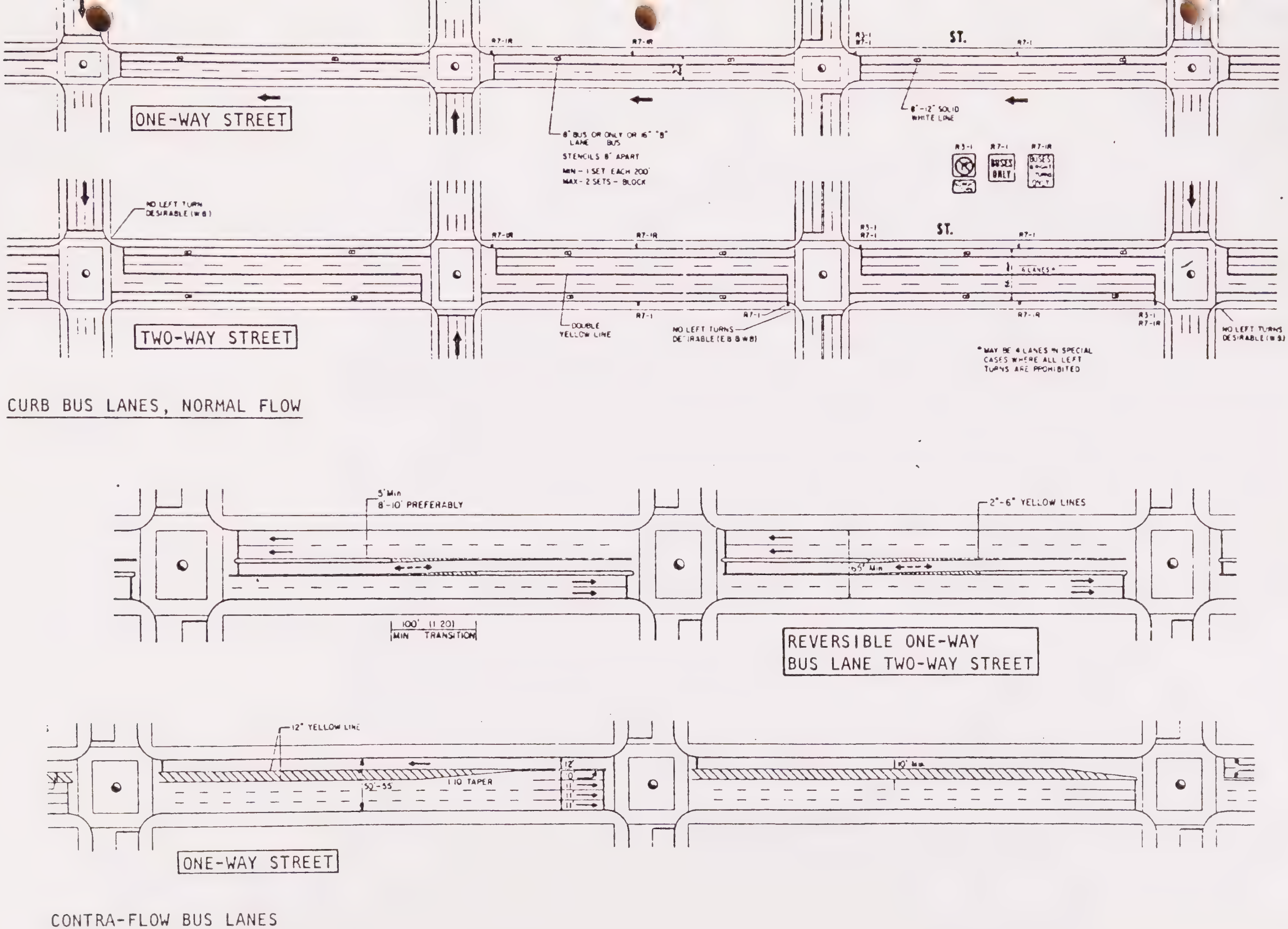
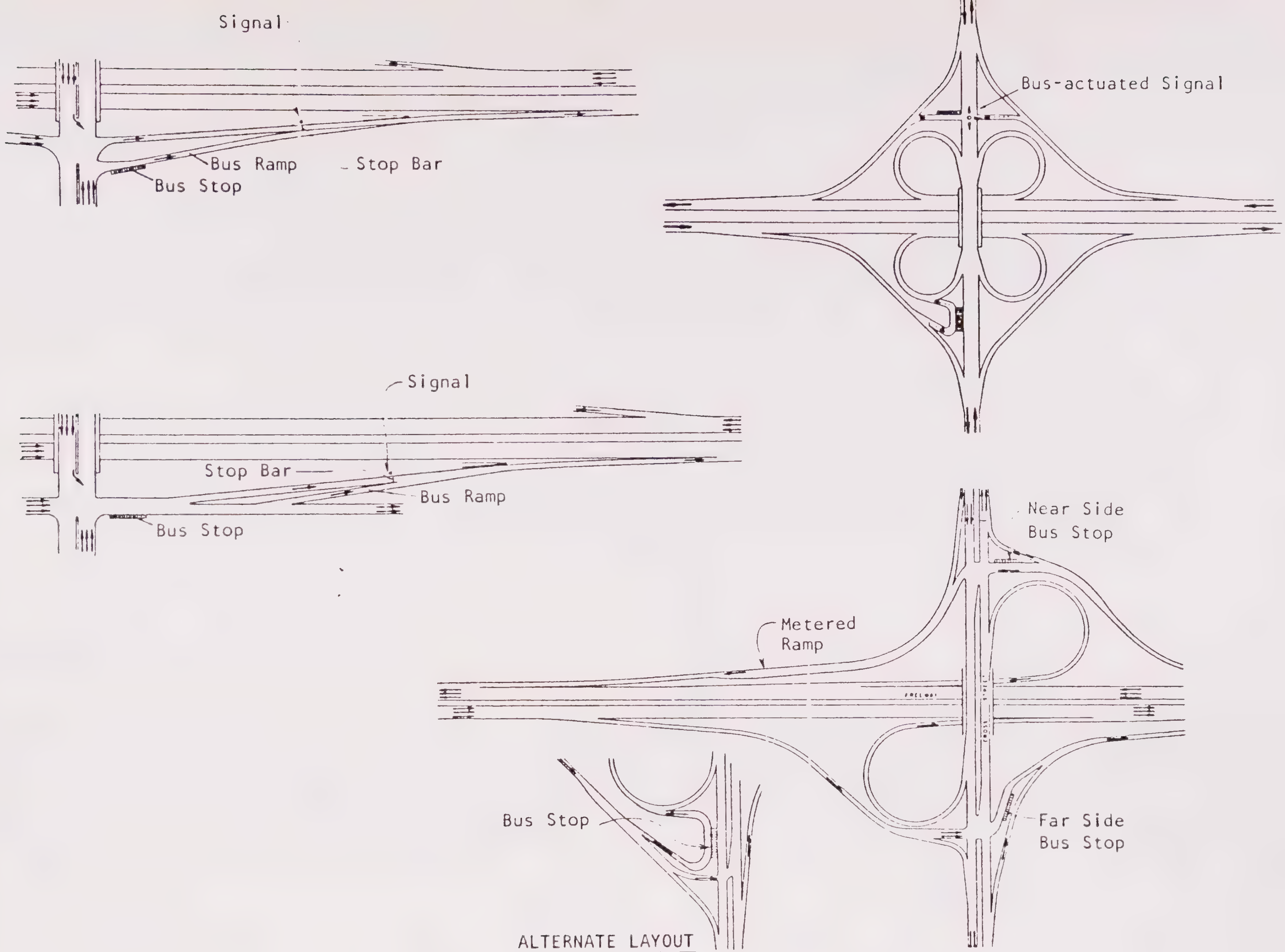


Figure 16
TYPICAL PRIORITY BUS LANE TREATMENTS

Source: Transportation Research Board's National Cooperative Highway Research Program Report #155



Source: Transportation Research Board's
National Cooperative Highway Research
Program Report #155

Figure 17
VARIOUS FREEWAY RAMP MODIFICATIONS
SHOWING BUS BYPASS LANES AT METERED RAMPS

Handicapped wheelchair lifts are assumed to be on all transit vehicles. In most cases the stations are at grade and wheelchair ramps would be provided to reach the low level platforms. Where aerial stations are required, both stairs and an elevator would be required.

The method of operation of transit systems, and subsequently station design requirements, is profoundly influenced by the type of fare collection system used. On conventional rapid transit systems, off-vehicle passenger fare-collection barriers are invariably used, which permits the train to be operated by a single attendant. On most other modes, the driver has the responsibility for fare collection. The principal shortcoming of this arrangement is that it prevents the effective operation of large, multi-door vehicles such as articulated buses or light rail vehicles, or the operation of trains of light rail cars under the control of a single driver. In Europe this problem has been solved by the almost universal adoption of self-service fare collection, in which the passenger is responsible for paying his own fare, and is required to show a valid ticket to policing inspectors upon request. This system has proved extremely successful, being popular with both operators and patrons, and it has made practical the operation of multi-door articulated buses and articulated light rail vehicles.

It is assumed for the purposes of this light rail evaluation that initially the fare box system will be used in Santa Clara County, but that at some major stations supplementary off-vehicle fare collection may be necessary to speed up operations, as ridership demand increases.

Station sites were primarily chosen to create transfer points with existing or proposed bus routes. Where practical, station stops were located on the far side of a crossing street. This was done to expedite the traffic signal pre-emption time on the cross street. A moving vehicle approaching a cross street takes less time to cross the street than a vehicle which must accelerate from a near side stop. The stations

are identified on the Transitway Plan and Profile Sheets which accompanied Working Paper No. 3 by names associated with their locales.

MAINTENANCE YARD

Maintenance facilities are required to ensure proper system operations. The basic facilities are similar for both bus and light rail systems and they perform the same basic functions of vehicle maintenance, vehicle storage and guidway and station maintenance.

The size of the maintenance and storage yard depends on the size of the vehicle fleet to be serviced and can be made smaller by providing other vehicle storage facilities elsewhere. The main maintenance yard area, however, should provide for the complete overhauling of vehicles, repair of vehicle components, and any other extensive modification of vehicles. These are time consuming operations and require the use of heavy duty lifting equipment. A major repair shop requires that most of its floor space remain at rail level, with large areas allocated for work on single units that are in the shop for prolonged periods of time.

For a light rail system, the proposed maintenance facility would consist of a shop area of approximately 50,000 square feet containing a heavy repair track, two running repair tracks, inspection track and facilities for wheeling, crewing, and painting. The repair tracks would all be fitted with inspection pits. In addition, there would be a need for a cleaning track, for interior cleaning and car washing. Vehicle storage would be outside, and would consist of between one and two acres of storage tracks. This could be combined with a few more acres for bus storage as well. Consideration must also be given for vehicular access and employee parking, either on the site or adjacent to it. Vehicular access will be required for the delivery of parts and equipment, and a rail spur track would be convenient for heavy materials best delivered by railroad.

The track and overhead wire maintenance departments will require small fenced enclosures to store their heavy components, such as rails, ties and overhead support poles. These facilities also would require highway access, and preferably rail access too. They do not need to be an integral part of the storage maintenance yard, but should be nearby. These total facilities, along with storage areas, require significant amounts of property, usually in the range of 10 to 15 acres, depending on car storage requirements. It will obviously be necessary to locate the proposed facilities in an area where such land use is acceptable, such as industrial areas.

The future possibility of a publicly-operated rail transit operation in Southern Pacific's Peninsula corridor suggests a yard location close to the present SP train depot. One such location is shown on the plan and profile sheets for the Vasona Corridor between San Carlos Street, Lincoln Avenue, and Auzerais Street. The area defined is about 14 acres and includes the existing County bus maintenance yard site. This location provides an opportunity not only to interface with the SP line, but also to combine administrative requirements and some storage areas for the County bus system with the transitway facilities.

Three alternate yard location sites have been shown on the plan and profile sheets near the junction of Winchester Boulevard and the West Valley Transportation corridor, near Curtner and the SP mainline and near Lick Junction. These sites do not interface with the SP commuter line, but they do all interface with the SPRR for freight delivery and would provide good centralized yard locations depending on which transit lines were to be eventually constructed first.

PARKING LOTS

Parking spaces were assigned to the various station sites based on preliminary 1990 patronage demand figures and on land availability. For planning purposes, an area of 100 cars/acre was assumed. This allows adequate area for driveways, access aisles and landscaping. All parking was assumed to be surface level. The following station/stops were assumed to require 600-car parking lots (6 acres):*

- De Anza
- Vasona Junction
- Camden Avenue
- Oakridge Mall
- Santa Teresa (near IBM)

The remaining 30+ station/stops were assumed to require 200-300 car parking lots (2-3 acres).*

RIGHT OF WAY

Minimum rightof-way requirements are based on the typical guideway crossections. The areas defined do not necessarily represent the optimum or final right-of-way "take" lines, but only indicate the minimum amount of land required to meet initial engineering design considerations. The Santa Clara County Transportation Agency staff was responsible for establishing the actual right-of-way "take" lines, which conform more to actual property lines, and estimating right-of-way costs. Figures 18 and 19 show the minimum transit right-of-way requirements.

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*In some cases the parcels required for the parking lots were slightly larger than necessary and the resulting yield was shown on the plan and profile sheets.

SOUTHERN PACIFIC REQUIREMENTS

As discussed in a meeting in San Francisco last January, Southern Pacific's design requirements and operating policies are understood to be as presented below:

- Under no conditions will joint operations of passenger transit vehicles and freight trains on a common set of tracks be permitted.

- The Southern Pacific's Vasona Branch line and Fourth Street Branch line are too narrow (50-foot wide rights-of-way) and contain numerous active freight spurs and industrial development so that they should not even be considered for shared use of rights-of-way with a facility. For these reasons, Southern Pacific has declined to provide any track maps or estimates of freight car siding movements for these two alignments.

- The Southern Pacific's Mainline, Lick Branch and Permanente Branch present sufficient access rights-of-way that they would consider selling or leasing the available excess for a transitway, provided that the following design requirements were met:

- Any transit facility must not cross any railroad lines, branches, spurs or sidings at-grade, so as not to interfere in any way with the SP's freight-train operations.

- Where a transit facility is planned to run alongside a railroad track at-grade, a 15-foot wide clearance must be maintained from the centerline of the nearest railroad track to a suitable fence completely separating the two rights-of-way. This requirement is necessary to provide SP with an eight to ten-foot wide maintenance roadway. Where there is no access possible to SP's tracks(s)

on the side opposite the transit facility, a 22-foot wide clearance must be maintained (adequate for a two-way roadway).

- The entire transit right-of-way must be separated by a suitable fence from the railroad tracks for at-grade operations, so as to ensure that pedestrian transit patrons will not be walking back and forth across SP's freight tracks.

Based on previous meetings held between the Transit District and Southern Pacific, it is also the consultant's understanding that the railroad feels that the design standards, height and width clearances and safety requirements for railroads as legally defined by the various General Orders of the California State Public Utilities Commission should be rigorously followed and adhered to.

In additon to, and in line with the requirements listed above, the following assumptions could be made.

- 15-foot clearance to piers of adjacent parallel aerial structures.

- Relocation of railroad at District expense.

- Limited relaxation of clearance requirements for short distances.

- Abandonment of apparently unused spurs.

While alignments were developed using these guidelines, their relaxation or modification may produce considerable savings. For this reason, where a significant saving seemed possible, alternate alignments were developed to aid in the assessment of the cost impacts imposed by these requirements. In some cases, alternate conditions were able to be analyzed without the aid of additional alignment development. Some

of the possible options which might warrant further investigation and analysis are:

1. Total acquisition of railroad branch line(s).
2. Joint use of trackage, with freight runs being made at night.
3. Reducing clearance requirements between transitway and railroad tracks.
4. Allowing at-grade crossing of spurs and lightly used branch lines.

CALIFORNIA PUBLIC UTILITIES COMMISSION REQUIREMENTS

Under existing law, the California Public Utilities Commission (PUC) has the power to determine and prescribe the manner of installation, operation, maintenance, use, and protection of all railroad/highway grade crossings. The PUC also has the power "to require where, in its judgment, it would be practicable, a separation of grades at any such crossing heretofore or hereafter established. . ." The PUC has a current policy of refusing the establishment of any new railroad/ highway grade crossings unless the two grades are separated. If an at-grade crossing were to be permitted, however, it would be required to follow the regulations developed by the PUC for protection and safety at all railroad grade crossings.

It is not yet clear whether or not the Public Utilities Commission would have legal jurisdiction over a light rail system constructed outside of a railroad right-of-way. If the PUC does have jurisdiction, they can control the number of at-grade street crossings allowed, and possibly even require the elimination of these two traffic conflicts altogether. Also PUC does not appear to have jurisdiction over municipal corporations,

such as San Francisco's Muni system, and may not have jurisdiction over the County Transit District. The PUC would not have jurisdiction over busways implemented outside of railroads R/W's.

Before an opening of a grade crossing can be permitted under PUC regulations, General Order No. 75-C requires the installation of one of the following standard sign and signal configurations:

- Pedestrian crossing - a rectangular sign indicating a crossing for pedestrians only.
- Pedestrian crossing - an automatic crossing signal used for pedestrian crossings.
- Private crossing - a standard octagonal sign in combination with a sign indicating a private railroad crossing.
- Public crossing - a standard railroad crossbuck.
- Public crossing - alternately flashing red lights in combination with a railroad crossbuck.
- Public crossing - alternately flashing red lights on a cantilever over the roadway, combined with flashing red lights and a crossbuck on the cantilever post.
- Public crossing - alternately flashing red lights on a cantilever combined with a crossbuck on the post.
- Public crossing - automatic crossing gates in combination with any of the flashing light configurations mentioned above.

The PUC also requires under General Order No. 75-C certain standards when a crossing is automatically protected:

- The automatic signals shall conform to the before-mentioned standard configurations, and the signals shall be activated 25 seconds plus or minus 5 seconds before the passage over the crossing of the normally fastest train.

- The signals shall cease to operate after the passage of the train.

- The signals shall operate in the same manner for reverse (back-up) movement of rail traffic.

- The number of flashes of each light per minute shall be 30 minimum, 55 maximum.

- Traffic signals near the railroad crossing shall be pre-empted by the railroad to avoid conflicting aspects of traffic and railroad crossing signals.

PUC General Order No. 26-D establishes vertical and horizontal clearance requirements for railroads. In general, these requirements were observed in establishing the horizontal and vertical alignments. Some of the controlling requirements which are of major significance are:

- 22 foot-6 inch (plus 6 inches for reballasting) overhead clearance above freight tracks.

- 15 foot clearance of transitway structures above streets and highways.

- 14 foot clearance above transitway tracks.

- 8 foot-6 inch side clearance to structures, such as station platforms, from centerline of freight track.

PUC General Order 95 specifies the requirements for electrical construction over, above, adjacent to, along or across railroads and street railroads. Some of the major requirements as applicable to this study are:

- Trolley contact wires overhead clearance of 19 feet; 14 feet in subways, under bridges, etc.

- Trolley contact wires crossing above freight railroads, 22 foot-6 inch clearance (plus 6 inches for reballasting).

AT-GRADE CROSSING POLICY

In order to keep costs to a minimum, at-grade crossings of streets were evaluated to determine their feasibility. Although the California Public Utilities Commission's policy currently requires grade separation of all new railroad/highway crossings, transit operations in Europe using modern control system technologies do permit safe and efficient operation of at-grade crossings.

Railroad grade crossing protection policies in California were determined years ago based on the operating characteristics of conventional railroad trains. Light rail vehicles and buses today have vastly different operating characteristics. The conventional railroad train has a deceleration rate as low as -1.4 feet per second per second. This compares to a light rail vehicle with a service deceleration rate of -5.0 feet per second per second, and an emergency deceleration rate of -9.0 feet per second per second. The conventional bus has a deceleration rate of -4.5 feet per second per second, and an emergency deceleration rate of -10 feet per second per second. These performance criteria are more nearly equal to those of a standard motor vehicle rather than those of a conventional railroad train. Therefore new light rail crossing

standards are possible, based on the above deceleration rates and the corresponding required service breaking distances for LRT and bus.

The possible crossing standards would require control equipment on-board the transit vehicles which would communicate information to sophisticated traffic controllers, which in turn would set the proper traffic signal pre-empt phases and communicate an "all clear" back to the transit vehicle. Transit vehicle operators would still retain final control and the ability to stop before entering the intersection, should anything go wrong. The following example illustrates the intersection control concepts being considered.

A transit vehicle is traveling parallel and on one side of a street and is about to approach an intersection of a cross street. At a given distance from the intersection, the transit vehicle passes over a pre-empt detector which signals the traffic signal controller at the down-stream intersection to initiate a clearance phase. This clearance phase stops all traffic which would be crossing the tracks and allows vehicles on the tracks and pedestrians sufficient time to clear the crossing. At the actual transit vehicle crossing point, crossing detectors would be in place to indicate any vehicle still present within the crossing. When the transit vehicle reaches the safe stopping distance point from the crossing, it passes over another detector/transmitter (verification point) which automatically activates the brakes on the transit vehicle if any vehicle is still on the crossing. Thus this control system has the potential to eliminate safety problems at all transit vehicle crossings. At the same time, this more efficient pre-empt operation of the intersection provides more green time for automobile traffic than the existing PUC crossing standards. The PUC standards were developed in order to clear a crossing of autos, assuming the approaching train would not be able to stop before entering the intersection.

This project evaluated the consequences of following both the PUC standards for at-grade crossing protection and the possible new standards described above.

Based on the analysis to date, there appear to be two promising courses of action available for protecting transitway crossings, in addition to PUC standards. In the first course, traffic signals only would be used to control movements at a transitway crossing. Railroad crossing warning flashers would not be used. They only tend to confuse the driver and they invite violation, since legally they are only a warning device. Railroad gates are not required, since traffic signals have the same legal meaning.

In the second course of action, traffic signals supplemented by railroad gates would be used to control transitway crossings. Again, railroad warning signals would not be used. The railroad gates would begin to close as soon as the appropriate traffic signal shows a "red" indication. The gates would function only as a "redundant" safety device. Under this option, the time lost due to the gates would be minimal since they would come down during the actual transit vehicle pre-empt phase. As the transit vehicle passed the verification point, the gate would already have initiated closing operation. With the verification point located at a safe stopping-distance point for the prescribed maximum transit vehicle approach speed plus one second away from the intersection, the gate would always be in a closed position by the time the transit vehicle reaches the emergency stopping point, and certainly by the time it actually arrives as the intersection. With this operating scheme, the gate offers the added protection when it is most needed -- just prior to entry of the intersection by the transit vehicle. The gate would be raised immediately after the transit vehicle has cleared the intersection. Motor vehicles traffic would be allowed to enter the crossing at the same moments. Since typically the gate would be located 30 to 50 feet

from the traffic stop line, it would take four to five seconds for the first vehicle to reach the gate after receiving a "green" indication, whereas after only four seconds the gate would be high enough for motor vehicles to pass underneath it. However, if railroad gates were required to be in a closed position prior to the transit vehicle's arrival at the verification point, then the delay to motor vehicle traffic would be significantly greater than under the strategy just discussed.

When crossings of the transitway and a street were analyzed to determine the impact to traffic, certain assumptions were required. The first assumption made was that the crossing would be constructed to its ultimate configuration. For example, the crossing of Saratoga-Sunnyvale Road at Rainbow Drive is now a "tee" intersection and Saratoga-Sunnyvale Road is four lanes with left turn lanes. When this crossing was analyzed, it was assumed Rainbow Drive-Saratoga/Sunnyvale Road was a full, four-leg intersection, with six lanes plus left turn on Saratoga-Sunnyvale Road and four lanes plus left turn on Rainbow Drive. The second assumption made was that each intersection involved would be controlled by a volume/density type of traffic controller equipment capable of special pre-empt phasing. The third assumption made was that the transit vehicle headways would be those presented in the table below, which are based on preliminary estimates of peak-hour patronage demands on the transitways in 1990 (See Working Paper No. 2 for further reference).

Table 3 ASSUMED TRANSIT VEHICLE HEADWAYS

Study Corridor	LRT	Articulated Bus	Conventional Bus
	VEHICLE HEADWAYS (Minutes)		
De Anza	5	3	2.5
Vasona	4	2.5	2
Blossom Hill Road			
Cambrian Park-Vasona	5	3	2.5
IBM-Cambrian Park	15	10	7
Monterey Highway	10	7	5
Guadalupe-Lick	10	7	5

The intersection, or street crossing interval, is assumed to be one half the vehicle headway because transit vehicles are assumed to be moving with the same frequency in both directions during peak-hours. For example, if the headway were 10 minutes, then the intersection could be pre-empted once every five minutes by a transit vehicle traveling in one direction or the other.

Using these assumptions, the currently available traffic counts and traffic projections for 1990, each transitway/street crossing was analyzed to determine if grade separation would be necessary in order to keep traffic congestion below a Level of Service 'D', as described in the 1965 Highway Capacity Manual. In general, most streets were found capable of being crossed at-grade where the transit vehicle crossing interval is two minutes or more. If transit vehicles were to be operated at crossing intervals of under two minutes and the crossing was pre-empted,

there would be some disruption and delay to motor vehicle traffic. It may be possible to run the transit vehicles at less than two-minute crossing intervals if the transit pre-emption is dependent on gaps in the auto cross-traffic. However, this would require platooning of transit vehicles or trains, which would then require longer station platforms. Determination of the minimum headway which could be achieved assuming transit vehicles did not pre-empt a crossing upon arrival would require extensive work and was not a part of this study.

Use of either conventional or articulated buses would require operating at crossing intervals of less than two minutes on the Fourth Street, Vasona, and part of the Monterey Highway corridors. To avoid degradation of motor vehicle traffic operation, major street crossings (four lanes or more) on these alignments would need to be grade separated. On the Fourth Street and Vasona lines, all but the most minor street crossings would have to be grade separated.

The PUC grade crossing protection regulations, General Order No. 75-C, Sections 12.1 and 12.2 state:

> "If, in a particular case, exemption from any of the requirements herein is desired, the Commission will consider the application for such exemption when accompanied by a full statement of the conditions existing and the reasons why such exemption is asked. It is to be understood that any exemption so granted shall be limited to the particular case covered by the application.
>
> Nothing herein shall be construed as limiting the trial installation of experimental grade crossing protective devices, provided the Commission has approved such plan in advance of the time the device is installed."

These statements allow for possible changes in the PUC regulations for special circumstances. Under these sections the control of transitway crossings by traffic signals could possibly be achieved. If the PUC

did not approve this control scheme and required compliance to the existing regulations, an inferior intersection operation would result.

For example, assume a transit line parallel and to one side of a street. A transit vehicle is approaching a cross street without a station/stop at 30 MPH every two minutes. Assume the intersection before installation of the transitway operated at 63 percent of Level of Service 'D''. With the proposed crossing control strategy described previously, there would be a 13-second loss of intersection green time with every passing transit vehicle. This results in an intersection capacity of 75 percent of Level of Service 'D'. If the current PUC regulation requiring 20 seconds of warning before the passage of the fastest train was required, an additional 17 seconds would be lost. This would cause the intersection to operate at 90 percent of Level of Service 'D' (congestion level). Alternatively the loss of green time due to a crossing transit vehicle can be related to minimum headways.

If we assume the intersection operation is allowed to deteriorate to 100 percent of Level of Service 'D', then the minimum transit vehicle intersection crossing interval would be every 80 seconds, or a headway in each direction of 160 seconds (almost 3 minutes), assuming an intersection control strategy according to current PUC regulations. With the crossing control strategy proposed here, the minimum intersection crossing interval would be 35 seconds, or a headway in each direction of 70 seconds (a little more than one minute), an improvement in the permitted transit vehicle frequency of 130 percent.

PATRONAGE CONSIDERATIONS

The alignment and station/stop locations proposed here included consideration of favorable ridership access in residential areas and proximity to major travel attractors in commercial and industrial areas. A thorough field investigation and travel review was made in each corridor to identify the major travel generators and attractors which were within a reasonable access distance. (See Working Paper No. 2, "Travel Market

Potential"). Travel models identified existing and future travel patterns and volume flows across the entire urban area of the County. Trip tables for home-work trips were skimmed for those trips which were in the "sphere of influence" of the five study corridors plus Southern Pacific's commuter railroad line and which were long enough to take advantage of a corridor transit system. The County Transit District's adopted 516bus plan was reviewed as to lines and headways for bus routes crossing or paralleling the study corridors. The County's adopted bikeway plan was also similarly reviewed. Each affected community's current General Plan was reviewed for the designated locations and types of future growth which would be compatible with transitway station/stops.

As a result of all the above inventory and analyses, some 50 station/stop sites were identified on the various alignment alternatives. The average station/stop spacing is about 0.8 miles, ranging from 0.4 miles to 2.0 miles apart. The staff of the Santa Clara County Transportation Agency subsequently reviewed these tentative station/stop locations and, with minor changes, approved them as being reasonably situated with respect to serving the County's transit needs in these corridors.

Later on, if a preliminary engineering project is undertaken on part or all of these corridors, more detailed station/stop site investigations would be undertaken, working closely with the individual neighborhoods and communities affected. For purposes of this feasibility study, however, these station/stop sites are felt to be reasonably appropriate.

Studies of various transit systems show that the majority of transit riders complete their trips by walking from their destination station or stop. If people cannot complete their trip by a short and convenient walk, usually less than four blocks (1/3 mile), many simply will not use transit when other travel alternatives are available to them. Where frequent and direct feeder bus connecting services are available, some people will ride transit using these feeder services, but not as many

as would be the case if station/stops were located within walking access distances. If connecting bus services are limited, poor or non-existent, the transitway ridership will be correspondingly reduced.

For these reasons, attempts were made to locate the station/stops as close as possible to major travel generators and attractors where physically feasible, so as to maximize pedestrian access potential, which is so vital to achieving a well-patronized transit system. Station/stops were also chosen for their transfer and interfacing capabilities with the major thoroughfares of the automobile/highway system and with the bus routes of the planned 516-bus system.

ENVIRONMENTAL FACTORS

The alignment and station locations proposed resulted from a multi-disciplined team effort which included environmental, land use and socio-economic considerations. Within the designated transit corridors an attempt was made to preserve and enhance the natural and "built in" environments, as well as minimize negative impacts. The following listing summarized environmental, land use and socio-economic factors which influenced selection of alignment and station locations. A more thorough examination and evaluation of these factors was presented in Working Paper No. 4.

Land Use

- General Plan Compatibility -- locations designated as transportation corridors.

- Growth Inducement -- opportunities to intensify land use around open sites, empty canneries, vacant land, etc., located in or nearby activity centers for station/stops to encourage intensification.

- Land Taken for Right-of-Way -- minimize acquisition required for transit ways by taking full advantage of opportunities for joint use with railroad or highway rights-of-way.

- Strengthen/Weaken Adjacent Land Use -- avoid where possible major station/stops in residential neighborhoods, especially single-family. Preference for locating transitways in busy arterial streets with commercial use. Preference for maintaining a low geometric profile on the transitway (visibility impact) and flat grades (noise impact) through neighborhoods.

Natural Environment

- Noise and Vibration -- avoid proximity to quiet residential neighborhoods; preference for busy streets.

- Visual -- Low transitway profile, with avoidance of elevated structures and overpasses where possible to do so.

- Parks and Open Space -- Avoid using these for transitway right-of-way at all cost if in public ownership (4f violation); opportunity for joint transitway open space enhancement along Los Gatos Creek.

- Archeologic and Historic Sites -- Avoid any destruction of such sites by moving transitway alignment.

Socio-Economic

- Transit Access -- Locate station/stops as close to high-density and transit-dependent areas as possible; also provide direct service to activity centers and major employers.

- Business and Housing Displacement -- Avoid taking as many units as possible, especially low-income family and elderly housing units.

- Traffic Intrusion -- Locate station/stops along designated major thoroughfares away from residences, schools, and churches.

ALIGNMENT REVIEW

This section presents a description of the alternate transitway alignments within each of the five study corridors. It also includes a discussion of the opportunities and constraints encountered in the five corridors and a narrative description of the alignments. A set of 57 transitway plan and profile sheets, a reduced example of which is shown in Figure 18, was transmitted under separate cover as part of Working Paper No. 3. They graphically show specific details of the alignments which were used as a basis for cost estimates and environmental impact analysis in this project.

The alignments presented are products of a multi-disciplinary design team approach incorporating the efforts of civil, structural and traffic engineers, transportation and urban planners, and transit technology experts. Where appropriate, alternate alignments have been shown to develop a range of solutions to aid in the assessment of cost impacts caused by various institutional and physical constraints. It should be noted that these alignments are of a preliminary nature and are intended only as a basis for study. They are subject to the review of the general public and interested agencies and do not constitute recommendations. In each case an attempt has been made to choose a reasonable solution which is representative of the costs and impacts to be expected in the given section. Consideration was given to using as much existing publicly-owned right-of-way as possible. In both the West Valley and Guadalupe Transportation Corridors an attempt was made to leave a viable strip of property intact to allow for maximum flexibility with regard to future development opportunites. In any case, minor location changes to the alignments shown should not affect the overall cost or feasibility of the transit system significantly.

Figure 13
SAMPLE OF PLAN AND PROFILE SHEETS ACCOMPANYING WORKING PAPER No. 3 (30% Actual Size)

Right-of-way and construction cost estimates and a discussion of the potential for development and/or redevelopment of land adjacent to the transitways are subjects included in subsequent chapters. Summary descriptions of the corridors and their various alignments are as follows:

Study Corridor #1, De Anza Branch, WVTC

This corridor extends from Cupertino southwesterly for seven miles to Vasona Junction, where it meets the Vasona and Blossom Hill Corridors, as shown in Figure 19. There are two right-of-way (R/W) opportunities for locating transitway facilities in this corridor. The first is within Southern Pacific's Permanente Branch RR right-of-way, and the second is within the designated right-of-way for the proposed West Valley Transportation corridor (State Highway 85), 75 percent of which is owned by the California Department of Transportation (Caltrans). From Saratoga Avenue to Vasona Junction, these two options have adjacent R/W's which would indicate a single common transitway alignment.

On the basis of proximity to the largest number of patrons, the West Valley Transportation Corridor alignment choice is preferable. This alignment is also preferable for a busway alternative because this 200-foot wide right-of-way is adequate, whereas the right-of-way which might be available in the SP Permanente Branch RR right-of-way is only adequate for a light rail line. Without moving the SP track, an additional seven feet of right-of-way would be required for a busway along the SP alignment.

With the exception of the rebuilding of the I-280/Foothill Boulevard interchange structure on the SP Railroad alignment, only one grade separation structure might be considered necessary on each of these two alignments. Southern Pacific has requested and will probably continue to insist on grade separation of all their railroad facilities. If they are able to sustain their position, a grade separation will be required on the West Valley Transportation Corridor alignment's crossing of the spur track servicing the Paul Masson winery, and on the SP Permanente Branch alignment's crossing of the railroad line near Saratoga Avenue.

Figure 19
DE ANZA CORRIDOR #1

The most difficult, and correspondingly most expensive, section in this corridor is the SP Permanente alternative between Simla Junction and Stevens Creek Boulevard. In this section, the SP Permanente Line was relocated onto highway right-of-way as a result of construction of I-280 and little or no excess railroad right-of-way now exists. This situation would therefore require considerable right-of-way acquisition and rebuilding of structures at the I-280/Foothill Expressway interchange. It may therefore be advantageous to terminate this alignment south of Stevens Creek Boulevard to avoid this expense in lieu of minimal ridership gains. However, if the transitway were ever to be extended to Palo Alto along the Foohill Expressway right-of-way, the alignment would have to pass through this section.

Traffic conditions on streets crossing these lines are such that all of the streets could be crossed at-grade by a light rail or bus transitway, assuming minor intersection modifications, and the traffic on all of them could be pre-empted in favor of transit if PUC regulations could be modified. These required modifications were discussed earlier in this report.

Both alternative alignments would have five different station/stops plus three common ones on the common alignment section between Saratoga Avenue and Vasona Junction. All eight of these station/stops would be at-grade platforms with the possible exception of the Vasona Junction station. At Vasona Junction, where the the De Anza Line joins the Vasona and Blossom Hill Lines, two of the three interchange legs would have to cross the SP rail line. If grade separation of this railroad/street crossing proves necessary, the Vasona station/stop would necessarily have to be on aerial structure.

Parking lots would be constructed at the various eight station/stops for between 200 and 600 cars, depending on the stop location. Bus, bicycle and pedestrian access facilities would be provided where appropriate.

Table 4
DE ANZA CORRIDOR CROSSING SUMMARY

Type	Alternate "A" SPRR Section		Alternate "B" WVTC Section		Alternate "A" & "B" Common Section	
	At-Grade	Grade Separated	At-Grade	Grade Separated	At-Grade	Grade Separated
Highways/ Expressways	0	1	0	0	0	0
Streets	9	0	5	0	4	0
Railroad Lines/ Branch Lines	1	0	0	0	0	0
Railroad Spurs	0	0	1	0	0	0
TOTALS	10	1	6	0	4	0

<u>Study Corridor #2, Vasona/Winchester</u>

The Vasona Corridor, as shown in Figure 20, begins at the SP Depot and extends southwesterly for 6½ miles along the SP Vasona Branch Line, the Southwest Expressway and Winchester Boulevard to Vasona Junction, where it joins the De Anza and Blossom Hill Lines. The opportunities for locating a transitway in this corridor are limited and are as follows:

- Purchase of the entire SP Vasona Branch right-of-way and compensation to shippers for loss of rail service.

Figure 20
VASONA CORRIDOR #2

- SP Depot to Meridian Avenue - SP right-of-way plus acquisition of private properties.

- Meridian Avenue to Bascom Avenue - located between SP track and Southwest Expressway using right-of-way from both; or, located in the median of a reconstructed Southwest Expressway.

- Bascom Avenue to Winchester Boulevard - SP right-of-way plus acquisition of private properties.

- Winchester Boulevard to Vasona Junction - located between the SP track and Winchester Boulevard using right-of-way from both; or, located in the median of a reconstructed Winchester Boulevard.

These right-of-way opportunities, though relatively straight and level, are very narrow and strictly define the possible alignments.

For purposes of this study, a route was chosen for the light rail alternative which would utilize railroad right-ofway as fully as possible without requiring major acquisition or reconstruction of railroad facilities. The busway alignment would be identical to that of the light rail, though requiring a 12-foot wider right-of-way, except for the section between Winchester Boulevard and Vasona Junction. In this section, the nature of busway facilites and associated problems concerning mistaken entrance onto the busway by unauthorized vehicles from the parallel traffic lanes indicates that a median location within Winchester Boulevard would be the preferred location for a busway.

This section on the Vasona Corridor with the greatest number of physical and right-of-way constraints is the northern-most section between the SP Depot and Interstate 280. This section constitutes 17 percent of the length of the Vasona Line. The area is congested with railroad facilities,

frequent street crossings, industrial development, a transformer station, a street underpass and a street overpass. Many of these conflicts could be attenuated with the use of a continuous aerial structure. Accordingly, two alternate alignments were developed for cost comparison purposes. One is predominately aerial, minimizing right-of-way acquisition, railroad disruption and traffic interference, and the other is predominately at-grade, resulting in less construction but much more right-of-way acquisition and traffic conflicts.

Optional vertical profiles, requiring grade separation structures, have been developed at the transitway crossings of Bascom Avenue, Hamilton Avenue and the SP Vasona Branch Line near Winchester Boulevard. The latter alternative was developed to evaluate the consequences of meeting Southern Pacific's request for full grade separation of facilities. The first two grade separation options, especially on the one at Hamilton Avenue. were developed to assess the cost of avoiding the serious adverse impacts on automobile traffic which would be caused by at-grade crossings of these major arterials.

Of the seven station/stops on the Vasona Line, it is possible that the two station/stops at Bascom Avenue and Lincoln Avenue would have to be aerial. All of the other five would be at-grade. Parking lots, with capacities of 200 to 600 cars, would be provided at various station/stops. Bus, bicycle and pedestrian access facilities would be provided where appropriate.

The entire Vasona Line is very narrow and extremely dependent on acquiring at least a portion of its right-of-way from Southern Pacific. Though Southern Pacific has stated that, under their present policy, none of their right-of-way in this corridor would be made available for transit use, the Vasona alignments, as presented in this report and depicted on

the accompanying plan and profile sheets, were developed using portions of SP right-of-way wherever it appeared practicable to do so. Additional right-of-way acquisition could be avoided in this corridor if agreement could be reached with Southern Pacific concerning complete acquisition of the Vasona Branch Line right-of-way, or possibly, for the light rail option, joint use of trackage. Joint use of trackage operations require building two new tracks for light rail and allowing railroad operations over one of these during non-transit hours.

Table 5
VASONA CORRIDOR CROSSING SUMMARY

Type	At-Grade Alternate		Partially Aerial Alternate	
	At-Grade	Grade Separated	At-Grade	Grade Separated
Highways/Expressways	0	4	0	4
Streets	15	3	11	7
Railroad Lines/ Branch Lines	2	0	0	2
Railroad Spurs	6	0	0	6
TOTALS	23	7	11	19

Study Corridor #3, Blossom Hill Branch, WVTC

The Blossom Hill Corridor begins with its connection to the De Anza and Vasona Corridors at Vasona Junction and follows the West Valley Transportation Corridor easterly for 10 miles to its junction with the Monterey Highway Corridor (See Figure 21). The transitway alignment developed in this corridor remains entirely within the limits of what has been designated as the West Valley Transportation Corridor (State Route 85), the primary

Figure 21
BLOSSOM HILL CORRIDOR #3

objective being to use publicly owned right-of-way wherever possible. About 50 percent of this corridor is presently owned by Caltrans.

This line is entirely at-grade, with the exception of the mandatory grade separation of State Highway 17 and the optional grade separation of Almaden Expressway, indicated to be desirable as a result of traffic impact studies. For a little over a mile the transitway is located in the median of Branham Lane between Union and Camden Avenues. This section on Branham Lane would have the greatest impact on local traffic circulation. Transitway median operation can only be crossed approximately every 2,000 feet if the transit vehicle is to pre-empt the traffic at each street crossing. Therefore Branham Lane would require extensive reconstruction with some new street crossings and many median closures of minor intersecting streets.

All of the nine station/stops on the Blossom Hill line would be at-grade, except Almaden Plaza which, if the Almaden Expressway crossing was grade separated, would have to be an aerial structure. Parking lots would be provided for from 200 to 600 cars at the various station/stops. Bus, bicycle and pedestrian access facilities would be provided where appropriate.

Recently several new homes have been constructed within the West Valley Transportation Corridor on private land. Approxinately 25 of these new homes would have to be removed to make room for the transitway.

Table 6
BLOSSOM HILL CORRIDOR CROSSING SUMMARY

Type	At-Grade	Grade Separated
Highway/Expressway	0	2
Streets	14	0
Railroad Lines/Branch Lines	1	0
Railroad Spurs	0	0
TOTALS	15	2

Study Corridor #4, SP Mainline/Lick Branch

This corridor begins at the SP Depot and follows the SP Mainline for 4½ miles southeasterly through San Jose to Lick Junction, then southerly for 3 miles along the SP Lick Branch Line to its intersection with the Blossom Hill corridor near the Oakridge Mall Shopping Center (See Figure 22).

The opportunities for a transitway in this corridor lie in using available railroad rights-of-way as much as possible, or the Monterey Highway Alternative described separately hereinafter. Along the SP Mainline section, some additonal right-of-way acquisitions would be necessary. Subsequent right-of-way and construction cost studies will attempt to determine whether it would be feasible to move the SP Mainline tracks laterally enough to accomodate a transitway entirely within the SP railroad right-of-way. A light rail facility could easily be accomodated within the SP Lick Branch Line with only minor relocation of railroad facilities. A busway in this same section would require either purchase of additional right-of-way, relocation of the entire Lick Branch railroad facilities, or acquisition of the total right-of-way.

The horizontal and vertical alignment developed for this corridor parallel the railroad alignments as closely as possible; thus, for topographic considerations, where the railroad is grade separated, the transitway alignments must also be grade separated. In addition, a grade separation would be required at the crossing of the SP Main Line near San Carlos Street. It may also be necessary to cross the Western Pacific Railroad's tracks between Minnesota Avenue and Almaden Road on an aerial structure.

All nine stations on the SP Mainline/Lick Branch are at-grade. Parking would be provided for from 200 to 600 cars at the various station/stops. Bus, bicycle and pedestrian access facilities would be provide where appropriate.

Figure 22
S.P. MAIN LINE/LICK CORRIDOR #4

Table 7
SP MAINLINE/LICK CORRIDOR CROSSING SUMMARY

Type	At-Grade	Grade Separated
Highways/Expressways	1	2
Streets	6	10
Railroad Lines/Branch Lines	1	1
Railroad Spurs	0	0
TOTALS	8	13

Alternate Study Corridor #4, Fourth Street RR/Monterey Highway

The Fourth Street RR/Monterey Highway Corridor extends southeasterly for 8½ miles from San Jose State University to the IBM complex at Blossom Hill Road and Monterey Highway (See Figure 23). This alignment begins along Fourth Street in downtown San Jose, passes under Interstate 280, proceeds along the SP Fourth Street Railroad Line, crosses over Tully Road and enters the Monterey Highway median. This alignment continues in the Monterey Highway median to Lick Junction, where the alignment leaves the median and enters the strip of land located between Monterey Highway and the SP Mainline.

The feasibility of using the Monterey Highway median north of Curtner Avenue and south of Lick Junction was also investigated; however, these locations showed no significant advantages while impacting traffic flow to a greater degree and providing inferior access at station/stops for transit patrons.

Figure 23
MONTEREY HWY./S.P.R.R. ALT. CORRIDOR #4

Study Corridor #5, Guadalupe Transportation Corridor

This corridor runs southerly from downtown San Jose along the Guadalupe River and Transportation Corridor for six miles to where it intersects the West Valley Transportation Corridor near Oakridge Mall (See Figure 24). The primary goal in locating an alignment in this corridor was to take advantage, wherever possible, of right-of-way already acquired by the State (Caltrans). About 75 percent of the Guadalupe Freeway R/W has already been purchased and cleared.

In the section between Willow Street and Curtner Avenue, the Guadalupe Transportation Corridor lies adjacent to and immediately to the west of the SP Mainline. Therefore the same alignment previously described for the SP Mainline/Lick Branch Corridor #4 was used for this section. Another common section with the SP Mainline/Lick Branch is a section between Chynoweth Avenue and the Blossom Hill Corridor alignment.

Major constraints affecting the location, other than right-of-way consideration, occur at the existing Guadalupe Freeway interchange with I-280 and in the major hill south of Curtner Avenue. In the first instance, the transitway must be located in the median of the partially constructed, but yet to be opened, Guadalupe Freeway. In the second instance, the hill south of Curtner would require a cut section approximately 40 feet deep and totaling 2,000 feet in length. Also, because of the Guadalupe Freeway's proximity to the SP Mainline between Curtner Avenue and Willow Street, the Guadalupe alignment would be forced to accept for topographic reasons several grade separations which are on the existing SP Mainline.

All of the seven station/stops on the Guadalupe Corridor alignment would be at-grade. Parking lots would be provided for from 200 to 600 cars and bus, bicycle, and pedestrian access facilities would be provided where appropriate.

The most difficult to construct and heavily impacted section of transitway in this corridor lies between Interstate 280 and Curtner Avenue. The SP railroad right-of-way is only 50 feet wide in most cases, with many spurs and sidings. Land use in the area is all older industrial and many properties have been developed with buildings and freight sidings immediately adjacent to the railroad right-of-way. Resolution of all of the many conflicts that occur in locating a transitway alignment in this area is not possible at this time. Therefore, alternate alignments have been developed for right-of-way and construction cost comparisons. An alignment using extensive aerial structures to solve these problems would amount to about two miles, or 25 percent of this alignment being aerial.

Of the twelve station/stops located along this corridor, the General Electric and IBM station/stops would be necessarily aerial because automobile traffic conditions are such as to warrant grade separation of the alignment at these locations. Additionally, the three station/stops located in the above mentioned narrow railroad right-of-way area could be aerial, depending on final resolution of the many conflicts. Parking would be provided for from 200 to 600 cars at the various station/stops. Bus, bicycle and pedestrian access facilities would be provided where appropriate.

Table 8
FOURTH STREET RR/MONTEREY HIGHWAY ALTERNATE CORRIDOR CROSSING SUMMARY

	At-Grade Alternate		Partially Aerial Alternate	
Type	At-Grade	Grade Separated	At-Grade	Grade Separated
Highways/Expressways	0	2	0	2
Streets	19	3	15	7
Railroad Lines/ Branch Lines	2	2	0	4
Railroad Spurs	2	0	0	2
TOTALS	23	7	15	15

Figure 24
GUADALUPE CORRIDOR #5

Table 9
GUADALUPE CORRIDOR CROSSING SUMMARY

Type	At-Grade	Grade Separated
Highways/Expressways	0	2
Streets	4	10
Railroad Lines/Branch Lines	1	1
Railroad Spurs	0	0
TOTALS	5	13

Considerable thought was given to the number of alternative alignments to be developed in this project. In some places subsequent right-of-way and construction cost investigations and cost trade-off analyses may indicate the advisability of relocating railroad lines or streets a few feet to avoid a particular right-of-way taking. In other areas, the possibility of acquiring a complete railroad right-of-way may even prove economically feasible. The possibility of joint use of trackage will be discussed further in subsequent chapters. In any event, the alignments as shown on the set of plan and profile sheets accompanying Working Paper No. 3 and the descriptions contained here in this report are not expected to vary significantly enough to affect the physical design requirements or overall construction costs appreciably. Therefore, even though other options and combinations of options may be analyzed later on during a preliminary engineering phase, it is felt that the alignments as described herein are reasonably representative of the physical conditions and solutions which would be encountered in any final alignment study, and constitute an appropriate basis for estimating construction cost requirements in this feasibility and alternatives analysis study.

CHAPTER IV

CAPITAL COSTS

The unit costs used in preparing the capital cost estimates for each alternative are based on the latest available information for bid prices, manufacturers estimates, and data developed recently by De Leuw, Cather for similar transit studies in Pittsburgh, Denver, and Los Angeles, as well as on an UMTA sponsored National Light Rail Study. Prices were updated to June 1976 dollars and adjustments were made for specific construction cost conditions currently prevailing in Santa Clara County.

It is important to note that these study estimates are order-of-magnitude and based upon limited field investigations and conceptual development of the alternatives for comparative study purposes. While this provides a valid basis for system comparison, more detailed cost estimates may eventually be required for the selected alternative based upon further field investigations, preliminary engineering, environmental impact studies and inputs received during all necessary public hearings. A contingency allowance of 25 percent has been included to cover unexpected or unforeseen situations which may arise during detailed design or construction.

The actual cost estimate quantities were primarily based on the alignments shown on the plan and profile sheets previously submitted with and described in Working Paper No. 3, "Alignment Definition." Costing for most components of the systems followed a standard procedure and emphasis was placed throughout on consistent treatment of the light rail and busway alternative transit systems under study. The flow chart presented in Figure 25 shows the basic costing sequence followed. The specific alignments used for costing obviously will be different from final selected alignments in some areas, but it is anticipated that the general mix of guideway and station types will remain reasonably the same.

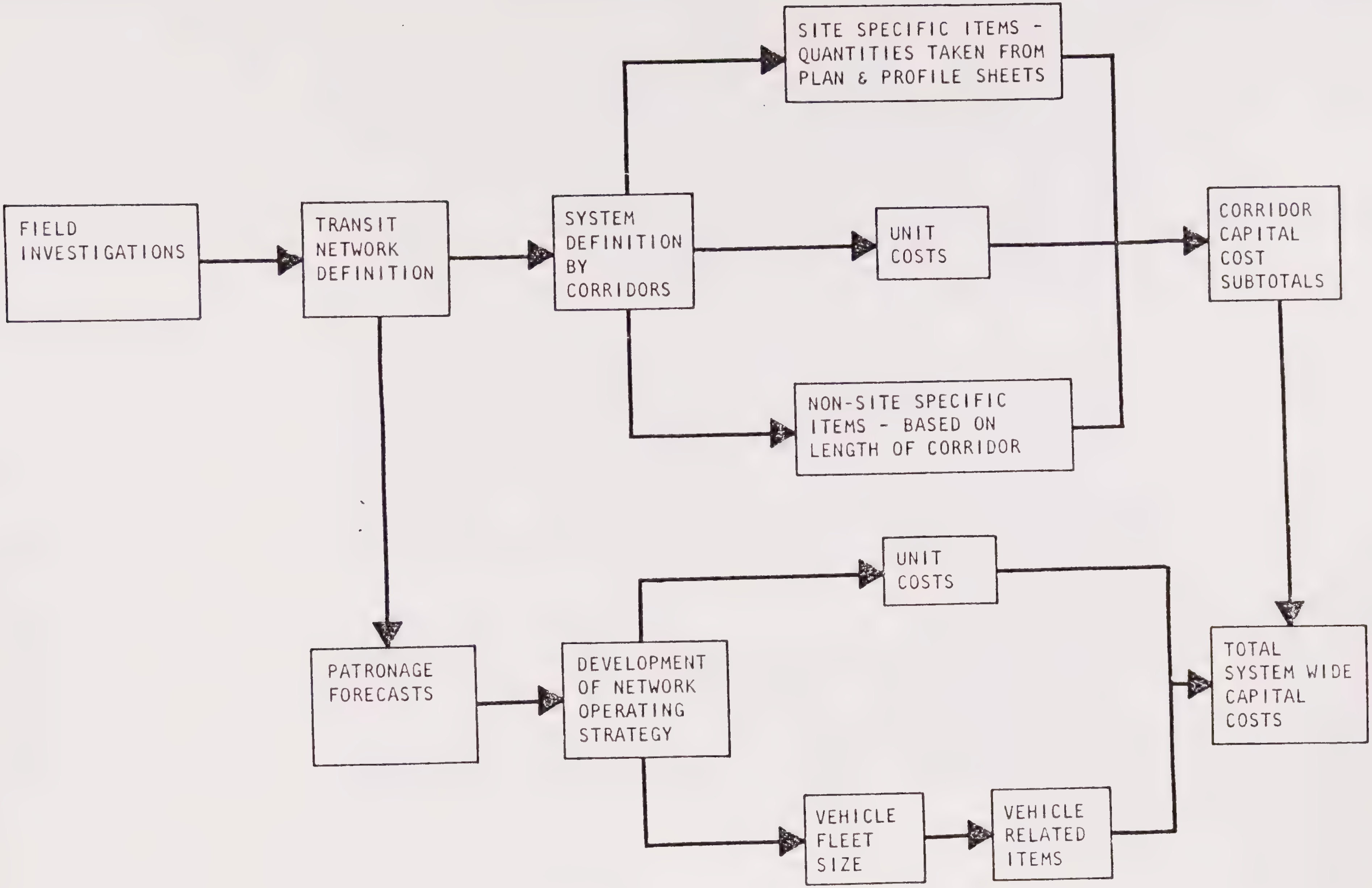

Figure 25
COSTING METHODOLOGY

CAPITAL COST ITEMS

The transitway capital cost estimates were prepared considering such individual cost elements as guideways, trackwork, power supply, control and communications, stations/stops, parking lots, street, railroad and utility relocations and reconstructions, yards, shops and maintenance facilities, right-of-way acquisition, vehicles, agency costs, design preparation and construction supervision, and a contingency allowance for unforeseen items. The capital cost items for bus systems were also broken down as appropriate for this mode.

CORRIDOR CAPITAL COST SUBTOTALS

The five corridors designated by the SCCTD board were listed earlier in Chapter I and are described in detail in Working Paper No. 3, "Alignment Definition." For each of the study corridors the following design standard subalternatives were defined and costed:

- "Base Case" Alternative
- "Meeting SP Requirements" Alternative
- "Higher Cost" Alternative
- "Lower Cost" Alternative

For some of the railroad corridor alignments, a fifth option called the "RR Buyout" alternative is also discussed.

The following sections define the differences between the various corridor cost subalternatives and describe the major capital cost differences for each.

"Base Case" Alternative

This design standard alternative is described in detail in Working Paper No. 3, and is shown by the solid profile line on the plan and profile

sheets (with at-grade crossings of most streets and railroad spurs) which accompanied that Working Paper.

The "Base Case" Alternative, as defined, is a workable solution which could be implemented with a fairly high degree of safety. It does not, however, always meet PUC regulations or railroad requirements as they now stand, and the feasibility of some of the assumptions has therefore not been verified. This alternative is generally consistent, however, with good, modern European light rail design practice.

"Meeting SP Requirements" Alternative

This design standard is the same as the "Base Case," except that this alternate would require grade separation of railroad and transit facilities at all railroad crossings and would require using a separate, fenced right-of-way when the transitway alignment is at-grade and adjacent to a railroad line.

The operating characteristics of this alternative are approximately the same as the "Base Case" Alternative. The only cost differences involved are:

- Increased guideway costs for the addition of grade separations at all railroad crossings;
- Increased guideway costs for an 8-foot high fence throughout those sections which are at-grade and adjacent to a railroad;
- Some additional station cost due to stations becoming aerial rather than at-grade;
- Additional station costs for pedestrian overpass structures over railroad tracks at appropriate stations;
- Right-of-way costs increased wherever the alignments are at-grade along a railroad to cover the additional cost of the wider section required for a separate, fenced right-of-way.

"Higher Cost" Alternative

This design standard is the same as for the "Base Case," with additional grade separations at all major arterial streets and at all railroad branch lines (still includes some at-grade crossings of railroad spur tracks and minor street crossings), plus the addition of higher amenities and architectural design standards at stations, and an increase in the amount of landscaping provided.

The average operating speed of the light rail alternative would be increased by about 30 percent (to 35 MPH) over the "Base Case" (27 MPH) by the addition of grade separations at all major arterial street crossings. It would also result in safer operations with less impact to automobile traffic. Transit preemption of automobile traffic at all remaining at-grade crossings with the busway alternative would be accomplished.

The costs vary from the "Base Case" Alternative in the following areas:

- Guideway costs were increased due to additional grade separations;
- Signalization and control costs were decreased because of fewer at-grade crossings;
- Landscaping costs were increased to allow for some additional beautification;
- Some additional station costs due to more aerial stations;
- Station costs were increased to allow for additional architectural treatment.

"Lower Cost" Alternative

This alternate assumes a minimal cost system, with right-of-way and structures shared with the railroad where possible; grade separations only at freeways and railroad mainline crossings; and minimal signalization without automatic train protection for the light rail system.

This alternate attempts to estimate the least expensive solution which might reasonably be achieved. For both Light Rail and Busway the operating standards would be lower than the "Base Case," with speed restrictions throughout. To minimize costs, some major at-grade crossings would not be preempted by Light Rail or Busway vehicles.

The costs vary from the "Base Case" Alternative in the following areas:

- Lower vehicle costs reflecting purchase of used PCC vehicles;
- Lower guideway costs due to fewer grade separations;
- Lower guideway costs due to shared freeway crossings with the railroad where possible on existing structures;
- Lower overall control costs due to minimal signal system with no Automatic Train Protection System, but some increased control costs due to more at-grade crossings.

As with the "Base Case" Alternative, the feasibility of some of these assumptions has not been completely verified. This alternative design standard is not believed to be desirable but has been included for the purpose of defining the absolute lower end of the capital cost range.

Discussion of "RR Buyout" Alternative Possibilities

This alternative primarily refers to possibilities which might be considered for the Vasona Corridor or for the northern end of the Fourth

Street RR/Monterey Highway Corridor where the transitway alignment is to be constructed within a narrow railroad right-of-way. For either of the transitway alternatives several different options are available if the railroad line is to be bought out entirely.

The first option would result in the same facility as any of the non-buyout alternatives, i.e., the construction of two light rail tracks or of a two-lane busway plus one relocated railroad track within the existing corridor. The only difference would be that the Transit District would buy the entire right-of-way, instead of only part of it as assumed previously, and then lease back a track to the railroad for freight use. The advantage of this approach is that the Transit District would then set its own operating rules and design standards in regard to at-grade crossings and required clearances. This might, in reality, be the only way in which the "Base Case" or "Lower Cost" alternatives, which have many at-grade railroad spur crossings, could ever be built. This solution would be used if it was found to be significantly cheaper than the aerial solution which meets SP requirements, or if SP would not sell only that portion of the right-of-way which is needed for aerial construction.

A second option, which applies to the light rail system only, would buyout the railroad corridor and then build two light rail tracks only, and allow freight movements on the light rail tracks during off-peak transit hours. This would require connecting spur tracks into the transitway tracks and it would also require that the Transit District get into the freight moving business.

A third solution which would cause more railroad freight service disruption but which would provide for cheaper transitway construction conditions would be to buyout the railroad and completely sever freight service. The transitway could then be built down the center of the right-of-way with no railroad traffic or spur tracks to be considered. This could amount to a substantial savings in construction costs, but the level of detail of the cost estimates made here will not adequately reflect the incremental differences. This solution would be used only if these savings were significantly more than the increased right-of-way

costs for severance of rail freight service, which would involve converting some existing rail shippers to truck loading operations, as well as buying out or relocating others. A more in-depth study of these options could be undertaken during the preliminary engineering phase if either the Vasona or Fourth Street branch railroad corridors is chosen for transit implementation.

The corridor capital cost subtotals are summarized in Table 10 on the following page. Cost breakdowns for the corridor subalternatives listed above for the light rail transitway are given in tables contained in Working Paper No. 6. Table 11 has been included in this report as an illustration of the kind of data contained in the tables.

It should be noted that these costs are corridor subtotals only and the following cost items have not been included here:

- vehicles
- Communications
- Maintenance Shops and Storage Yard
- Agency Cost (for the above items)
- Contingency (for the above items)

The above items are dependent on the vehicle fleet size and are added into the systemwide capital cost estimate totals in the following section.

Costs produced for this project are believed to be not only relatively correct vis-a-vis different corridors and systems, but also reasonably representative in absolute magnitude. During preliminary and final design, standards will be set which may be at variance from assumptions made in this analysis and this could result in cost differences for certain system components. The assumptions on which the costs are based are realistic and have been consistently applied so as to not distort the results of the alternatives analysis.

The data contained in Table 10 permit relative comparisons to be made among the five corridors under study. Thus, in absolute terms, the

Table 10 SUMMARY OF CORRIDOR CAPITAL COST SUBTOTALS

Corridor Description	Alternate	Base Case	Meeting SP Requirements	Higher Cost	Lower Cost
		(June 1976 dollars)		(Cost in $million)	
De Anza Corridor No. 1 Alternate "A" - 8.56 mi.	Light rail	47.5	53.7	57.5	42.8
	Busway	30.1	37.0	40.8	30.1
De Anza Corridor No. 1 Alternate "B" - 6.74 mi.	Light rail	32.3	36.4	40.5	28.6
	Busway	17.6	22.1	26.5	17.6
Vasona Corridor No. 2 - 6.12 mi.	Light rail	41.2	52.4	61.3	35.4
	Busway	37.0	48.5	72.2	34.2
Blossom Hill Corridor No. 3 - 9.30 mi.	Light rail	60.1	60.1	71.7	53.0
	Busway	40.1	40.1	52.7	38.2
S.P. Mainline/Lick Corridor - 7.55 mi.	Light rail	45.5	47.4	52.7	41.3
	Busway	32.0	34.2	39.5	32.0
Fourth Street RR/ Monterey Highway Alternate No. 4 - 7.78 mi.	Light rail	56.8	67.6	81.0	51.1
	Busway	43.4	55.5	69.8	40.1
Guadalupe Corridor No. 5 - 6.09 mi.	Light rail	38.1	39.2	44.5	34.7
	Busway	26.6	27.8	33.5	26.6

Table 11

CORRIDOR CAPITAL COST SUBTOTALS

LIGHT RAIL "Base Case" Alternative	De Anza Corridor No. 1 Alternate "A"	De Anza Corridor No. 1 Alternate "B"	Vasona Corridor No. 2	Blossom Hill Corridor No. 3	S.P. Lick Corridor No. 4	Monterey Highway Alternate Corridor No. 4	Guadalupe Corridor No. 5
	(June 1976 dollars)			(Cost in $ millions)			
Guideway	7.49	5.39	9.82	11.53	10.37	12.05	10.41
Trackwork	5.14	4.04	3.67	5.58	4.53	4.67	3.65
Electrification	5.99	4.72	4.28	6.51	5.29	5.45	4.26
Control	4.94	3.82	4.12	5.32	3.95	4.99	3.11
Landscaping	0.43	0.34	0.31	0.47	0.38	0.39	0.31
Noise barriers	0.29	--	0.23	0.11	0.25	0.05	0.04
Stations	0.24	0.24	0.21	0.59	0.30	0.97	0.91
Parking lots	2.40	2.40	1.44	5.88	3.24	3.48	2.52
Street reconstruction	2.27	0.25	1.68	1.71	•1.25	4.12	0.53
Relocation of RR tracks	0.10	--	0.46	--	--	0.66	--
Utility relocation	1.98	0.19	0.37	0.16	0.31	0.41	0.11
Right of way	2.69	1.69	2.85	5.10	2.61	3.33	1.37
Subtotals	33.96	23.08	29.44	42.96	32.48	40.57	27.22
Agency Cost (for above items only) 15%	5.09	3.46	4.42	6.44	4.87	6.08	4.08
Contingency (for above items only) 25%	8.49	5.77	7.36	10.74	8.12	10.14	6.81
Corridor Subtotals	47.54	32.31	41.22	60.14	45.47	56.79	38.11

CORRIDOR QUANTITY SUMMARY

	De Anza Corridor No. 1 Alternate "A"	De Anza Corridor No. 1 Alternate "B"	Vasona Corridor No. 2	Blossom Hill Corridor No. 3	S.P. Lick Corridor No. 4	Monterey Highway Alternate Corridor No. 4	Guadalupe Corridor No. 5
Miles of at-grade guideway	8.56	6.74	5.50	8.65	7.01	6.97	5.60
Miles of aerial guideway	--	--	0.62	0.65	0.54	0.81	0.49
Number of at-grade street crossings	13	10	14	14	7	16	4
Number of at-grade railroad crossings	3	2	8	--	1	4	1
Number of at-grade stations	8	8	7	8	10	9	7
Number of aerial stations	--	--	--	1	--	2	2

corridor with the greatest light rail capital cost subtotal under the "Base Case" design standard assumption, for example, is the Blossom Hill Corridor -- $60.1 million. Under the "Meeting SP Requirements" and "Higher Cost" assumptions the Fourth Street/Monterey Highway Corridor has the greatest cost subtotal -- $67.6 million and $81.0 million, respectively. For the "Lower Cost" design standard assumption, the Blossom Hill Corridor is again the most expensive at $53 million. The smallest capital cost light rail subtotals are for the De Anza Corridor Alternative Alignment "B" under all of the design standard assumptions. It can also be seen from Table 10 that the busway capital cost subtotals for each corridor are less than the corresponding light rail subtotals except in the case of the "Higher Cost" Alternative in the Vasona Corridor.

Comparison of busway and light rail costs should be made with great care and complete understanding of the conditions involved before reaching any conclusions as to relative costs. This is especially true when comparing data for different cities where local site conditions and different assumptions as to operating conditions might exist. For instance, the type of profile (and hence the type of guideway construction required) can be quite significant, as shown below.

Item	Cost Per Mile for Construction ($1,000)					
	At-Grade		Aerial		Underground	
	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway
Guideway	900	1,000	7,000	8,000	18,000	27,000
Trackwork	600	NA	600	NA	600	NA
Electrification	700	NA	700	NA	700	NA
Control	450	200	450	200	450	200
TOTALS	2,650	1,200	8,750	8,200	19,750	27,200

Thus, it can be seen that for these four major cost elements the light rail costs can be considerably higher, about the same, or considerably less than busway costs depending upon the type of construction involved.

As an illustration of how operating assumptions can affect the relative costs, even for at-grade construction, it should be realized that if it is assumed that railroad freight operations can take place using the light rail tracks but would require construction of a rail track to supplement the busway, and if refurbished PCC cars are operated under manual controls, it is likely that under these conditions the total systemwide light rail alternative costs would be equal to, or perhaps even less than, busway alternative costs.

SYSTEMWIDE TOTALS

As explained earlier, the corridor capital cost estimate subtotals shown in the preceding section were not complete network totals. In order to obtain a total capital cost figure, a specific network configuration must first be defined and then patronage forecasts made, operating strategies worked out, vehicle fleet size requirements established, and vehicle-dependent cost items estimated and added to the sum of the subtotals for all of the corridors included in the network.

The following sections define complete networks for each of the transit mode alternatives, including the bus preferential treatment and bus system alternatives, and show complete systemwide capital cost totals. These are summarized in Table 12. Many other networks could also be defined by combining only selected, different corridors or by mixing transit alternatives. The following networks are those which were defined for the patronage forecasts and development of operating strategies as was described previously in Working Paper No. 5, "Patronage Forecasts." These networks served to indicate the relative performance of all the modes in each of the corridors under study.

Table 12	SUMMARY OF SYSTEMWIDE CAPITAL COST TOTALS			
	(June 1976 Dollars) (Costs in $Millions)			
Transit Alternative	Base Case	Meeting SP Requirements	Higher Cost	Lower Cost
Light Rail	267.5	294.0	348.0	210.4
Busway	174.2	202.7	276.1	166.2
Bus Preferential Treatment	39.6			
Increased Local Bus Service	66.7			
Baseline Bus System	68.3			

For any of the transit alternatives, the baseline transit system assumed for Santa Clara County in both 1975 and 1990 consists of two major components: (1) the local county bus system, and (2) the Southern Pacific commuter railroad. The local county bus system assumed is the adopted 516-bus system currently being implemented in Santa Clara County. Cost totals for its implementation are shown for comparative purposes in this report as the Baseline Bus System capital costs. These costs were not included in any of the other alternative cost totals but the existence of this system in slightly modified form as a feeder bus network was considered to be a part of all other transit alternatives and its operating costs are added to the operating costs of any other transit alternative.

Baseline Bus System

The baseline local bus system assumed for both the current and future level of development is the adopted 516-bus system currently being implemented. This system, shown earlier in Figure 3, consists of 46 bùs routes covering the urban area of the County on the major arterial street system. Out of the 46 routes, about half will operate at 15-minute headways in the peak periods and half at 30 minutes. Heavily traveled transit corridors such as El Camino Real/The Alameda and Foothill Boulevard/Stevens Creek/San Carlos will have buses scheduled every 7.5 minutes. During peak hours, 425 buses will be in active service.

The capital costs for the elements of this system are given in Table 13. It should be noted that these are theoretical replacement costs as of June 1976 and have been established so as to provide compatibility with other alternatives during the economic analysis tasks.

Increased Local Bus Service Alternative

This alternative would simply upgrade the assumed local baseline 516-bus system which was shown in Figure 3, by adding an additional 500 buses to

Table 13	SYSTEMWIDE CAPITAL COST TOTALS			
	(June 1976 Dollars) (Costs in $Millions)			
Baseline Bus System	Quantities	Network Subtotals	25 Percent Contingency	Network Totals
Curbside Shelters	100 each	0.40	0.10	0.50
Vehicles	516 conventional	41.28	0	41.28
Communication	516 vehicles	2.06	0.52	2.58
Maintenance Yard & Shops	516 vehicles	8.26	2.07	10.33
Right of Way for Maintenance Yard	Lump sum	4.12	1.03	5.15
Subtotals		56.12	3.72	59.84
Agency Cost 15%				8.42
Network Total				68.26

the same network in order to double the service frequency on all of the routes. The only capital improvements assumed for this alternative were the purchase of the additional buses, the cost of additional communication equipment, and the cost for the expansion of the maintenance and storage yard facilities. An additional 200 bus shelters were also assumed for placement throughout the network. The cost elements making up the $66.7 million total systemwide capital cost of this alternative are shown in Table 14.

Bus Preferential Treatment (TSM) Alternative

The Bus Preferential Treatment Alternative does not follow thé alignments described previously. Therefore, the following map and location descriptions are included to describe in site-specific terms the network costed for this alternative (see Figure 26).

Within the five study corridors designated for this project, roadway facilities were sought out which could afford priority treatment and improved travel speeds for bus vehicles during peak-periods. Candidate facilities were ramp-metered freeways and six-lane expressways and arterial streets capable of being preempted and permitting the installation of one or more reserved bus lanes. In all five corridors, some highway facility was found which was either already sufficient or was scheduled to be improved which would allow implementation of some form of bus preferential treatment facilities. Articulated buses were assumed for this bus alternative, but conventional buses could also be used, again at the added expense of requiring a larger fleet size and number of operators.

The systemwide costs of $39.6 million for this alternative are broken down by major elements in Table 15 and the minimum time required for implementation is shown by Figure 27.

Table 14 SYSTEMWIDE CAPITAL COST TOTALS

Increased Local Bus Service Alternative	(June 1976 Dollars) (Costs in $Millions)			
	Quantities	Network Subtotals	25 Percent Contingency	Network Totals
Curbside Shelters	200 each	0.80	0.20	1.00
Vehicles	500 conventional	40.00	0	40.00
Communication	500 vehicles	2.00	0.50	2.50
Maintenance Yard & Shops	500 vehicles	8.00	2.00	10.00
Right of Way for Maintenance Yard	Lump sum	4.00	1.00	5.00
Subtotals		54.80	3.70	58.50
Agency Cost 15%				8.22
Network Total				66.72

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Reserved Bus Lane and Signal Pre-emption

Freeway with Priority Entry Ramps

Auto Park-and-Ride Lots

Bus Priority Entry Points

Figure 26
BUS PREFERENTIAL TREATMENT NETWORK

Table 15 SYSTEMWIDE CAPITAL COST TOTALS

Bus Preferential Treatment (TSM) Alternative	Quantities	Network Subtotals	25% Contingency	Network Totals
	(June 1976 dollars)		(Costs in $Millions)	
Roadway				
Normal Flow Lane in Arterial Street	30 lane miles	0.17	0.04	0.21
Contra Flow Lane in Arterial Street	24 lane miles	1.10	0.28	1.38
Intersection Modifications	25 each	0.50	0.12	0.62
Freeway Ramp Modifications	10 each	1.00	0.25	1.25
Control				
Energy Emitters	72 vehicles	0.07	0.02	0.09
Energy Detectors and Phase Selectors	80 each	0.40	0.10	0.50
New Traffic Signals	20 each	1.20	0.30	1.50
Ramp Metering System	Assume given	--	--	--
Curbside Shelters	65 each	0.26	0.07	0.33
Parking Lots	6500 spaces	7.80	1.95	9.75
Right of Way for Parking Lots	65 acres	3.25	0.81	4.06
Vehicles	72 articulated	10.08	2.52	12.60
Communication	72 vehicles	0.29	0.07	0.36
Maintenance Yard & Shops	72 vehicles	1.50	0.37	1.87
Right of Way for Maintenance Yard	Lump sum	0.69	0.17	0.86
	Subtotals	28.31	7.07	35.38
	Agency costs 15%			4.25
	Network total			39.63

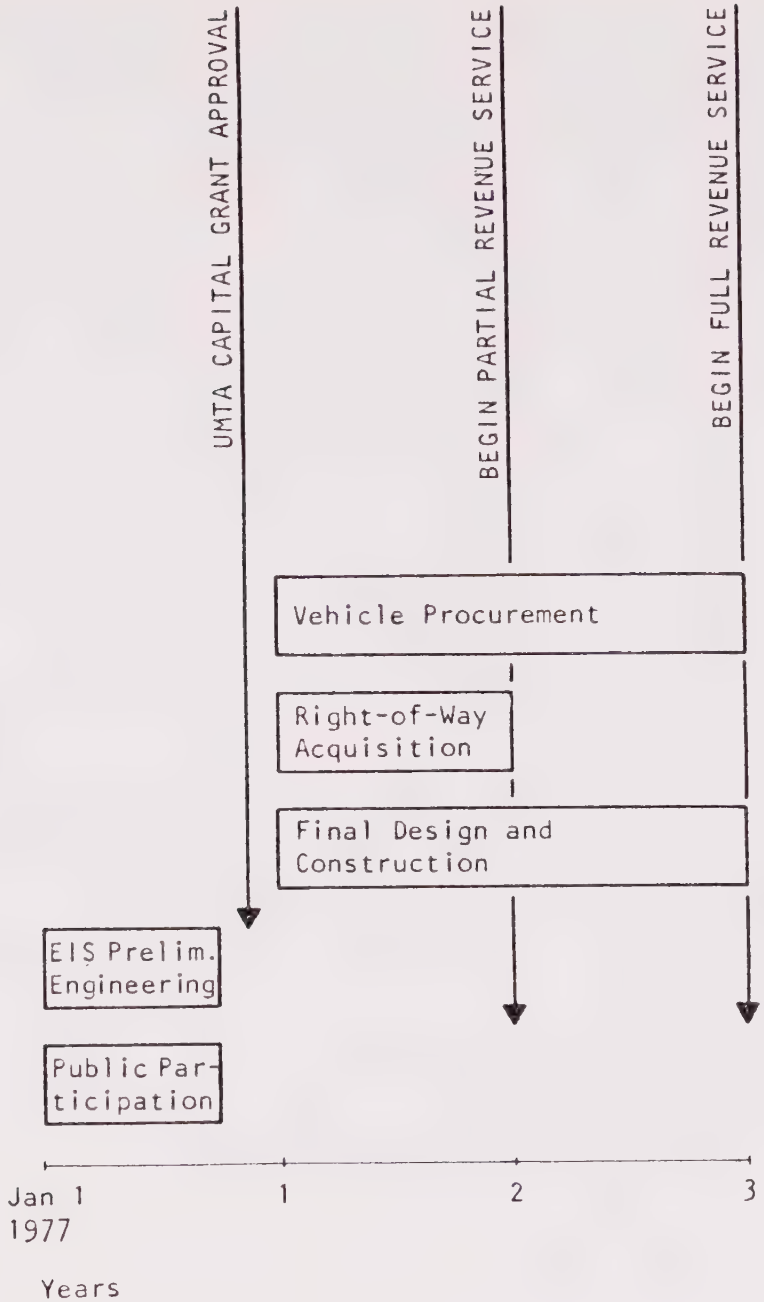

Figure 27
MINIMUM TIME FOR BUS PREFERENTIAL TREATMENT IMPLEMENTATION

Busway Alternative Networks

The systemwide busway capital cost estimates are shown for the "Base Case" in Table 16. Similar tables were also developed for each of the various design standard subalternatives described earlier and the results are summarized in Table 12.

Comparable to the light rail systemwide estimates, they were based on the network shown in Figure 28. For estimating purposes a 60-foot articulated bus was assumed for all cases. If conventional buses were used, a larger vehicle fleet size would be necessary which would increase the operating costs, and the impact on automobile traffic at preempted at-grade street crossings would be increased due to shorter transit headways.

Inspection of the data presented earlier in Table 12 indicates that if a busway were built in all five designated corridors, the total system costs would range between $166.2 million and $276.1 million, depending upon the design standards followed. A comparison of systemwide total capital costs for the busway and light rail alternatives indicates the following major areas of differences for the "Base Case" design standard, for example:

Guideway:	light rail is $ 6.8 million less expensive
Trackwork:	light rail is $25.6 million more expensive
Electrification:	light rail is $29.8 million more expensive
Control:	light rail is $16.0 million more expensive
Vehicles:	light rail is $20.6 million more expensive

Together, these five items account for more than 90 percent of the net total systemwide cost differences between the "Base Case" light rail and busway alternatives.

Figure 29 shows the minimum time required for implementation of the busway network. As was the case with the bus preferential treatment alternative discussed earlier, this estimated implementation schedule

Table 16

SYSTEMWIDE CAPITAL COST TOTALS

(June 1976 dollars) (Cost in $ millions)

Busway "Base Case" Alternative	De Anza Corridor No. 1 Alternate "B"	Vasona Corridor No. 2	Blossom Hill Corridor No. 3	Lower Portion of SP Lick Corridor No. 4	Monterey Highway Alternate Corridor No. 4	Downtown Connection from 4th St. to the S.P. Depot	Network Subtotals	25% Contingency	Networ Totals
Guideway	6.07	10.95	13.04	4.66	13.56	1.43	49.71	12.43	62.14
Trackwork	--	--	--	--	--	--	--	--	--
Electrification	--	--	--	--	--	--	--	--	--
Control	1.03	2.47	1.26	0.56	2.81	1.03	9.16	2.29	11.45
Landscaping	0.34	0.31	0.47	0.14	0.39	0.07	1.72	0.43	2.15
Noise barriers	--	0.30	0.11	0.10	0.05	--	0.56	0.14	0.70
Stations	0.24	0.21	0.59	0.12	0.97	0.15	2.28	0.57	2.85
Parking lots	2.40	1.44	5.88	1.44	3.48	--	14.64	3.66	18.30
Street reconstruction	0.25	5.14	1.71	0.88	4.12	0.70	12.80	3.20	16.00
Relocation of RR tracks	--	0.46	--	--	0.66	--	1.12	0.28	1.40
Utility relocation	0.28	0.52	0.16	0.15	0.41	0.15	1.67	0.42	2.09
Right of way	1.98	4.60	5.40	1.25	4.57	--	17.80	4.45	22.25
Vehicles	75 x 140,000/vehicle =						10.50	2.63	13.13
Communication	75 x 4,000/vehicle =						0.30	0.07	0.37
Maintenance Yard & shops							1.50	0.37	1.87
Right of way for maintenance yard							0.69	0.17	0.86
						Subtotals	124.45	31.11	155.56
						Agency cost 15%			18.67
						Network total			174.23

34.08 Miles of Guideway

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Figure 28
FIVE-CORRIDOR TRANSITWAY NETWORK
+ SPRR USED IN PATRONAGE FORECASTING

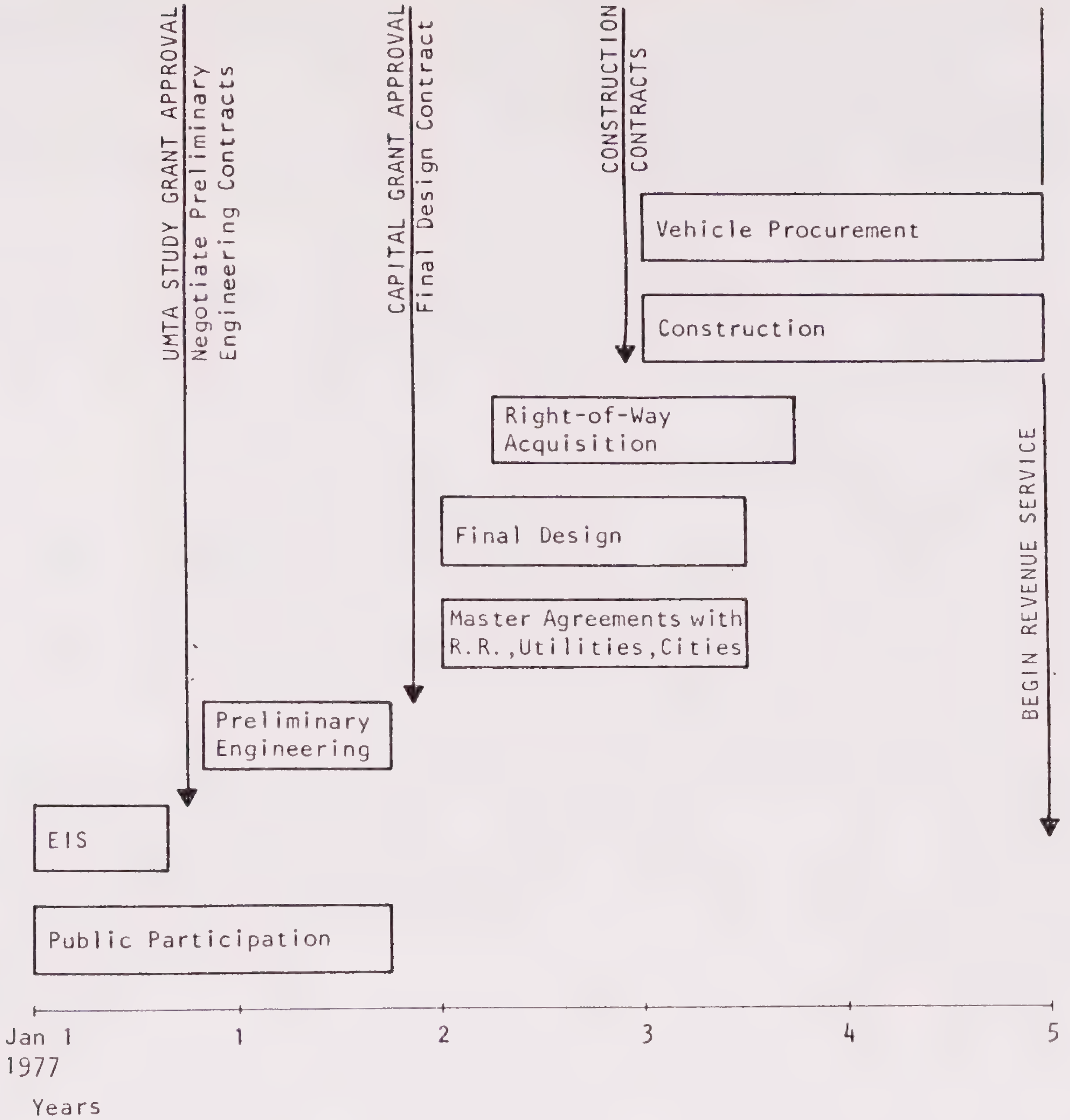

Figure 29
MINIMUM TIME FOR BUSWAY SYSTEM IMPLEMENTATION

was prepared for use in economic and financial analyses and indicates that a minimum of three years of inflation increases need to be added to the 1976 cost estimates contained in this report for financial planning purposes.

Light Rail Alternative Networks

The systemwide light rail capital cost estimates are shown for the "Base Case" in Table 17. Similar tables were also developed for each of the various design standard alternatives described previously and the results were summarized earlier in Table 12. They were all based on the network shown in Figure 28, and for all except the "Lower Cost" light rail alternative, a six-axle, articulated car similar to the Boeing vehicle was assumed. For the "Lower Cost" alternative the purchase of used and reconditioned PCC vehicles such as San Francisco's Muni cars was assumed. It was estimated that these used vehicles could be purchased for about $10,000 each and rebuilt for about $40,000 each. If these vehicles are not available, similar small PCC vehicles can be purchased new from Europe for about $200,000 per vehicle. The use of these smaller vehicles does require a larger fleet size than is required with the Boeing-type vehicles, however, and the operating costs would have to be increased accordingly.

It can be seen from the data contained in Table 12 that if a light rail line were built in all of the corridors under investigation, total system costs would range between $210.4 million and $348.0 million, depending upon the design standards followed. Changing from "Base Case" standard to "Meeting SP Requirements" would increase costs by just under 10 percent; changing from "Base Case" to "Higher Cost" would increase the total systemwide costs by about 30 percent, while a shift to "Lower Cost" standards would involve a reduction of about 20 percent.

Figure 30, which shows the minimum time in which a light rail system could be implemented in Santa Clara County, was prepared for use in the economic and financial analysis presented in Working Paper No. 7. Most

Table 17

SYSTEMWIDE CAPITAL COST TOTALS

Light Rail "Base Case" Alternative	De Anza Corridor No. 1 Alternate "B"	Vasona Corridor No. 2	Blossom Hill Corridor No. 3	Lower Portion of SP Lick Corridor No. 4	Monterey Highway Alternate Corridor No. 4	Downtown Connection from 4th St. to the S.P. Depot	Network Subtotals	25% Contingency	Network Totals
				(June 1976 dollars)		(Cost in $ millions)			
Guideway	5.39	9.82	11.53	4.14	12.05	1.30	44.23	11.06	55.29
Trackwork	4.04	3.67	5.58	1.70	4.67	0.78	20.44	5.11	25.55
Electrification	4.72	4.28	6.51	1.99	5.45	0.91	23.86	5.97	29.83
Control	3.82	4.12	5.32	1.76	4.99	1.78	21.79	5.45	27.24
Landscaping	0.34	0.31	0.47	0.14	0.39	0.07	1.72	0.43	2.15
Noise barriers	--	0.23	0.11	0.10	0.05	--	0.49	0.12	0.61
Stations	0.24	0.21	0.59	0.12	0.97	0.15	2.28	0.57	2.85
Parking lots	2.40	1.44	5.88	1.44	3.48	--	14.64	3.66	18.30
Street reconstruction	0.25	1.68	1.71	0.70	4.12	0.70	9.16	2.29	11.45
Relocation of RR tracks	--	0.46	--	--	0.66	--	1.12	0.28	1.40
Utility relocation	0.19	0.37	0.16	0.13	0.41	0.10	1.36	0.34	1.70
Right of way	1.69	2.85	5.10	1.11	3.33	--	14.08	3.52	17.60
Vehicles	45 x 600,000/vehicle =						27.00	6.75	33.75
Communication	45 x 5,000/vehicle =						0.23	0.06	0.29
Maintenance Yard & shops							8.00	2.00	10.00
Right of way for maintenance yard							0.69	0.17	0.86
						Subtotals	191.09	47.78	238.87
						Agency cost 15%			28.66
34.08 Miles of Guideway						Network total			267.53

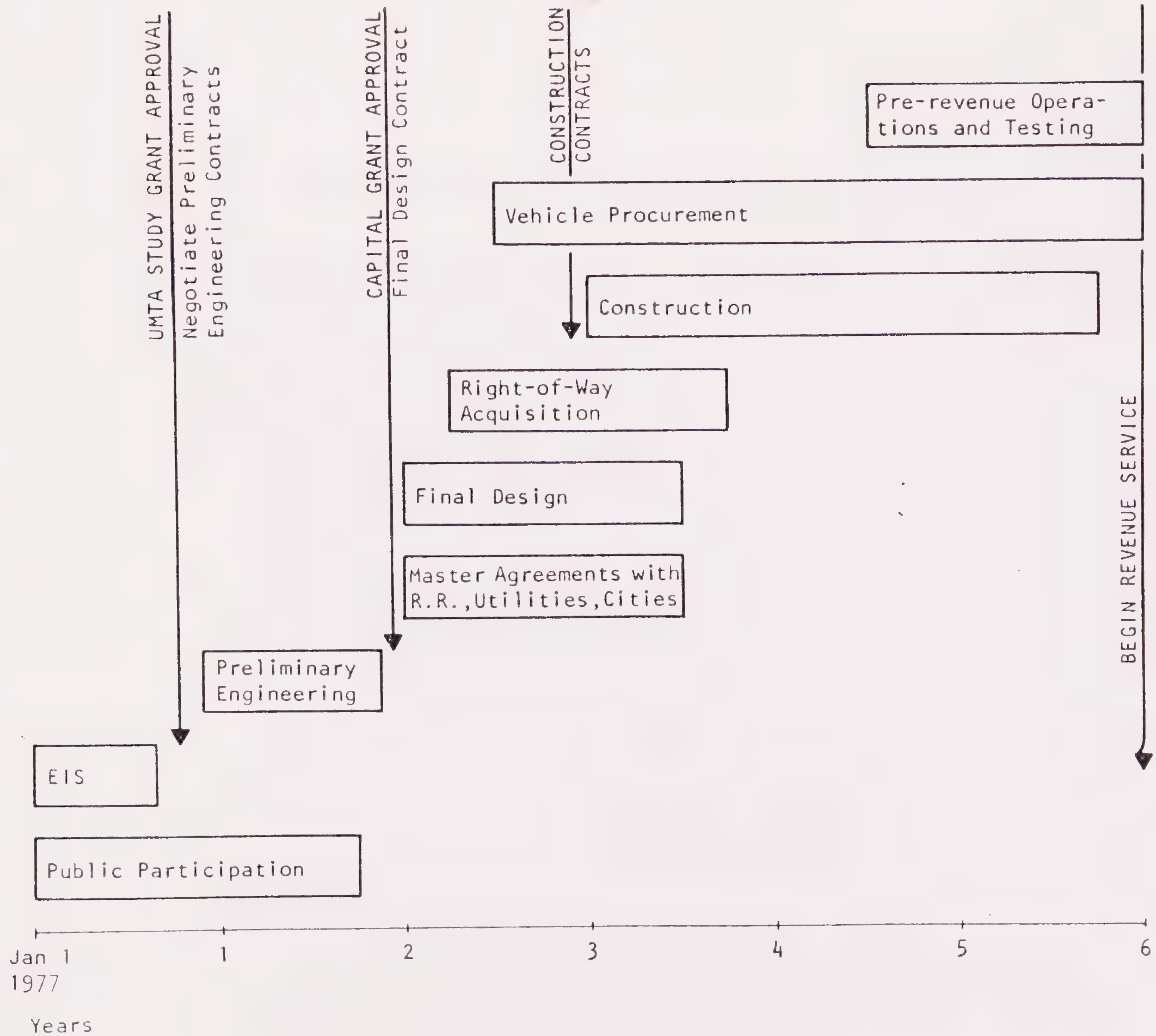

Figure 30
MINIMUM TIME FOR LIGHT RAIL SYSTEM IMPLEMENTATION

of the capital costs described in this report fall under the vehicle procurement, construction, and right-of-way acquisition categories, and as indicated in the figure, they will all have to have a minimum of three years of inflation increases added to them for financial planning purposes.

The preliminary engineering phase could commence after adoption of a Final Action Plan by the Transit District Board. At the District's discretion, it may or may not want to seek UMTA money to fund the preliminary engineering studies, which would include more refined and detailed engineering analysis, cost estimates and patronage forecasts for a selected transit mode alternative, a defined design standard/ service level option, and specific corridor(s) in accordance with the Board's approved Final Action Plan and community participation. Upon completion of the preliminary engineering study, in which detailed cost estimates and refined patronage forecasts would be made, and an accompanying EIR, the District would be in a position to apply for and receive a Federal capital grant for final design and construction of the system. Final design would include any final design changes due to responses to community wishes, environmental impact mitigation, utility or railroad company requests, etc., and would produce the required contract documents and specifications necessary prior to issuing a call for construction bids.

CHAPTER V

PATRONAGE FORECASTS AND EVALUATION

This chapter describes the methodology, major assumptions and "givens" underlying the patronage forecasting work, briefly discusses the modal split modeling process, and assesses the principal findings resulting from the numerous patronage tests made for the transit alternatives under consideration. It describes a number of sensitivity tests made to determine the impacts on transit ridership resulting from varying such basic input parameters as fare levels, speed, headway, station spacing, network extent, auto operating costs and alternative future land use scenarios.

Patronage forecasts were made for the following basic alternative transit systems:

- Baseline Bus
- Low-Capital-Cost Improved Bus Service (two versions)
- Busway Transit
- Light Rail Transit

A great deal of numerical data was developed in the course of this phase of the study and the major findings are presented in detail in Working Paper No. 5. For the sake of brevity, this chapter focuses primarily on the most significant results related to differences in patronage among modes, differences among corridors, highlights of the sensitivity tests and evaluation of these results. An evaluation of the patronage forecast results for the several transit alternatives follows and includes sections on transportation service effectiveness, impacts on existing transportation systems, and accessibility/mobility measures.

The information contained herein was determined using the best available land use/demographic projections and the best available transportation

modeling tools, given the time and budget constraints of this project. The results are felt to be reasonable and accurate enough for purposes of making relative comparisons between the transit alternatives. A note of caution is in order, though, in that the patronage figures are based on existing transportation models and data, some of which are now more than a decade old. The figures reported herein should be interpreted with this in mind. They should be used to inform judgments and not as substitutes for judgment. It is believed, however, that the absolute patronage values contained herein are of the correct order-of-magnitude and that the relative differences and tendencies shown reasonably reflect current attitudes and characteristics which influence travel behavior in Santa Clara County.

TRANSPORTATION SERVICE EFFECTIVENESS

1975 Systemwide Estimates

Table 18 shows the 1975 transit patronage estimates. Today's 236-bus fleet serves about 5,000 peak-hour and 40,000 daily riders. To help provide insight into how the patronage model performs, an estimate was made of how many riders would be attracted to the County's proposed 516-bus system if it were in operation today. This forecast indicated that the expanded system would attract about 85,000 daily riders, or a little more than double the existing transit ridership. This result was deemed to be reasonable. The model was then used to estimate what the 1975 patronage might be if light rail service were in existence now, supported by the 516-bus fleet for collection-distribution and local service. It was found that total transit ridership would increase to 100,000 trips -- 21,000 on the light rail lines and 79,000 on the bus network. This represents about 2.2 percent of the total daily trips currently made in the County.

Figure 31 shows the expected peak-hour riders on the light rail system's lines if they were in place and operating today.

Figure 31
1975 LIGHT RAIL TRANSIT PATRONAGE
FORECAST RESULTS
Numbers Shown Are AM Peak-Hour Volumes

Table 18
1975 TRANSIT PATRONAGE FORECASTS BY MODE

Alternative	Peak-Hour Trips		Daily Trips	
	By Transit	% of Total	By Transit	% of Total
236-Bus Existing System	5,000	1.8	40,000	0.9
516-Bus Planned System	10,500	3.7	85,000	1.9
Five-Corridor Light Rail Plus SPRR and 516-Bus System	12,500	4.4	100,000	2.2

1990 Systemwide Forecasts by Mode

The estimated 1990 ridership for each alternative is summarized in Table 19. Inspection of the data contained in this table indicates that the 1,000-Bus Fleet Alternative would attract 9,000 more peak-hour riders in 1990 than the 516-Bus Baseline system, an increase of 60 percent. The Bus Preferential Treatment (TSM) Alternative is expected to attract some 5,000 additional peak-hour riders in 1990 in comparison with the Baseline Bus Alternative, an increase of 33 percent. Similarly, the Busway Alternative would attract 5,000 additional peak-hour riders while the Light Rail Alternative would attract 6,500 additional riders, increases of 33 percent and 43 percent, respectively. Note that the busway and light rail plus SPRR alternatives would carry between 40 and 50 percent of all County-wide peak-hour transit riders in 1990, even though installed in only five corridors.

Figure 32 graphically illustrates the transportation service effectiveness of the alternative transit improvements for the five study corridors. The comparison is made on a 1990 daily transit ridership attraction basis.

Table 19
1990 SYSTEMWIDE TRANSIT PATRONAGE FORECASTS BY MODE

Alternative	Peak-Hour Trips		Daily Trips	
	By Transit	% of Total	By Transit	% of Total
Baseline Bus (516-Bus Fleet)	15,000	3.8	120,000	2.0
Low-Capital-Cost Improved Bus				
• 1000-Bus Fleet	24,000	6.0	170,000	2.8
• Bus Preferential Treatment (TSM)	20,000	5.0	140,000	2.3
Busway Transit				
• On Busway	8,700	2.2	60,000	1.0
• On Local Buses	11,300	2.8	90,000	1.5
System Total	20,000	5.0	150,000	2.5
Light Rail				
• On Light Rail	10,000	2.6	70,000	1.2
• On Local Buses	11,500	2.9	90,000	1.5
System Total	21,500	5.5	160,000	2.7

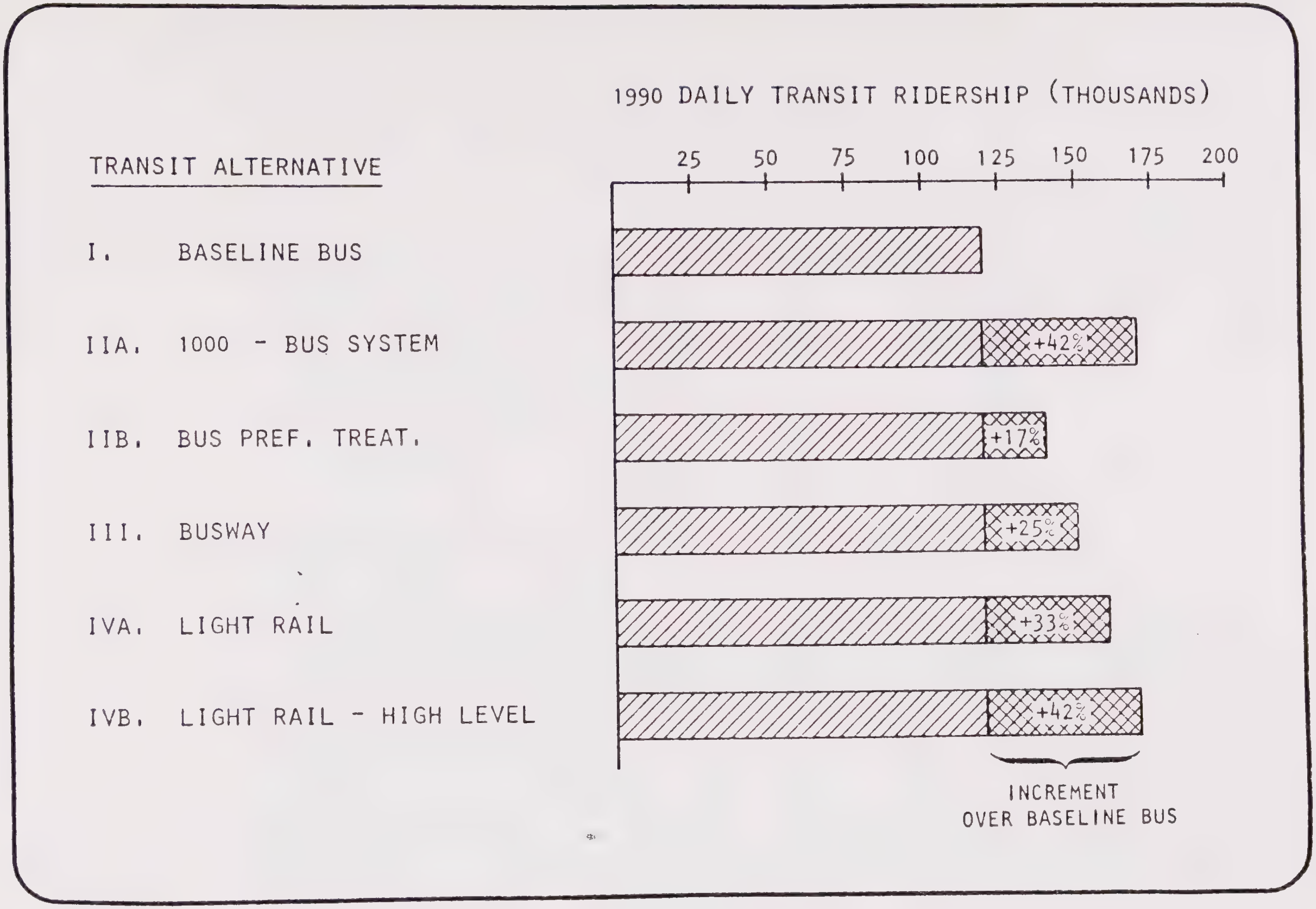

Figure 32
RELATIVE RANKING OF TRANSIT ALTERNATIVES PATRONAGE

1990 Transit Ridership Forecasts By Corridor

Figures 33, 34 and 35 illustrate the expected 1990 AM peak-hour ridership volumes forecast for each alternative in the five study corridors.

Figure 33 shows that the maximum line loads for the Bus Preferential Treatment Alternative would occur on the three radial spokes radiating out from central San Jose -- the I-280/Highway 17 corridor, the Almaden Expressway corridor, and the Monterey Highway corridor. All three of these corridors exhibited peak-hour transit volumes of about 2,000 riders per hour assuming high-speed, express bus services. A number of these bus riders would desire to transfer to SP trains at the San Jose depot. Assuming a quick and convenient transfer arrangement were established, about 2,400 peak-hour riders would transfer to the Peninsula commuter rail service in 1990.

Figure 34 shows the expected 1990 peak-hour transit ridership volumes on the five-corridor plus SPRR Busway Transit Alternative. The Almaden and the Monterey Highway corridors were joined together near General Electric at Curtner Avenue. The addition of about1,300 Almaden area riders to 2,000 Monterey Highway area riders resulted in a peak load point volume of 3,300 riders per hour on the common line segment. The Vasona corridor exhibited the second highest peak-hour volume with about 2,000 riders. About 650 riders were contributed to this total at Vasona Junction by each branch of the West Valley Transportation Corridor -- the De Anza branch and the Blossom Hill Road branch. The number of busway riders desiring to transfer to SP Peninsula trains at the San Jose depot in the AM peak-hour in 1990 is estimated to be about 2,600 riders.

Figure 35 shows similar results for the Light Rail Transit Alternative in 1990. In general, light rail ridership volumes on the five study corridors were forecast to be about 15 percent higher than the busways due to the light rail system's slightly higher average speeds and greater comfort and reliability. The Almaden and Monterey Highway corridors were joined together near General Electric, just as in the Busway

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Figure 34
BUSWAY TRANSIT PATRONAGE FORECAST RESULTS
Numbers Shown Are AM Peak-Hour Volumes

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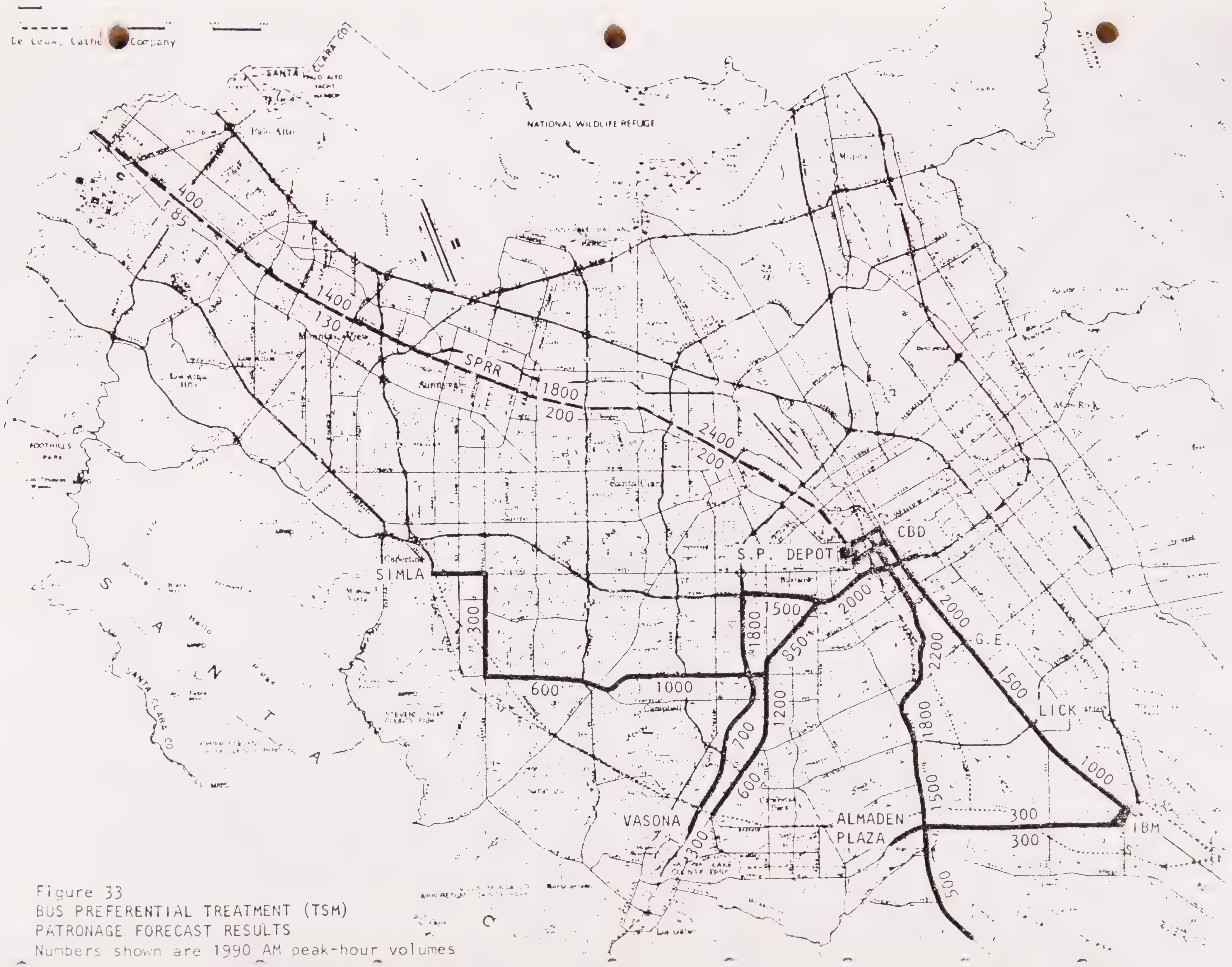

Figure 33
BUS PREFERENTIAL TREATMENT (TSM)
PATRONAGE FORECAST RESULTS
Numbers shown are 1990 AM peak-hour volumes

De Leuw, Cather & Company

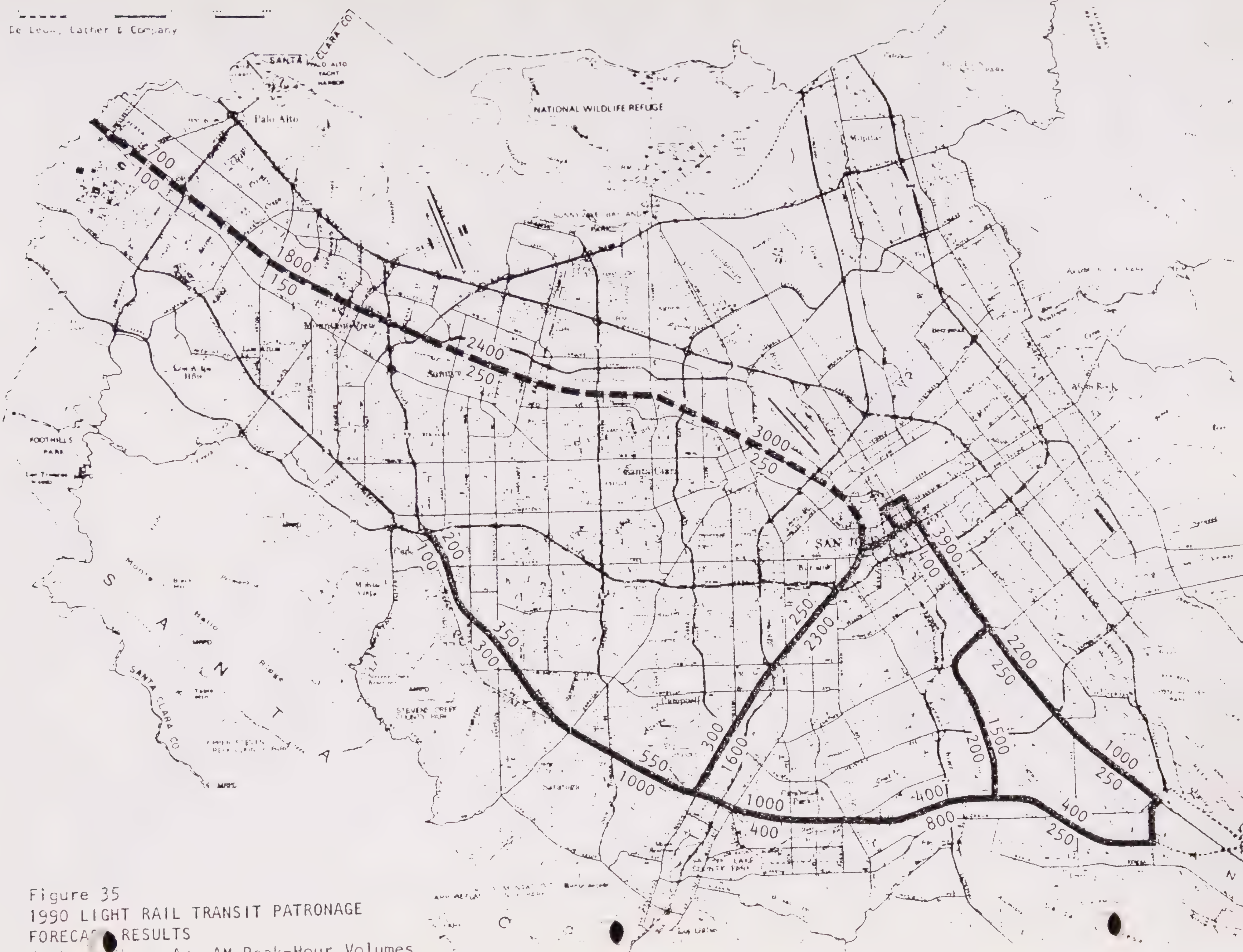

Figure 35
1990 LIGHT RAIL TRANSIT PATRONAGE
FORECAST RESULTS
Numbers Shown Are AM Peak-Hour Volumes

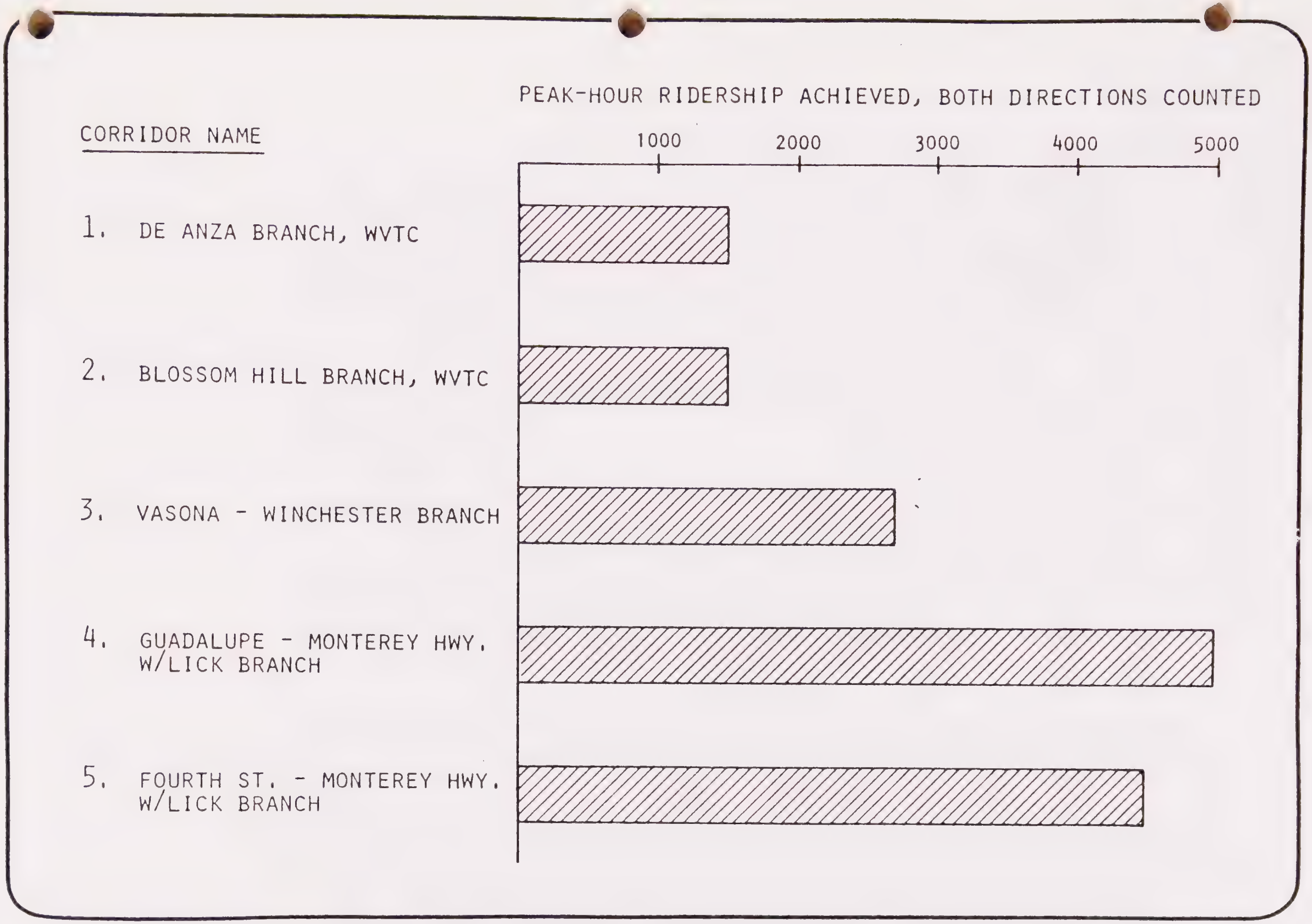

Figure 36
RELATIVE RANKING OF FIVE CORRIDORS 1990 PEAK-HOUR PATRONAGE

alternative. An alternate alignment choice is available along the SP's Lick branch line for servicing the Almaden area and would move this juncture of the two corridors south about two miles to Lick Junction. Ridership is not expected to differ appreciably for either alignment choice.

About 1,600 riders per hour on the Almaden line would combine with about 2,300 riders per hour on the Monterey Highway line to make 3,900 riders per hour on the common line section proceeding northward along the SP's Fourth Street branch railroad line to downtown San Jose. If this common line were located in the Guadalupe Freeway (Rte. 87) right-of-way through Willow Glen, about 550 (14 percent) more riders per hour would be expected, or a total of 4,450.

The Vasona corridor emerged as the second-highest in 1990 peak-hour ridership volume with about 2,300 riders. The two branches of the West Valley Transportation Corridor are expected to contribute 800 riders each to the Vascona's line volume at Vascona Junction. The number of AM peak-hour light rail transit passengers desiring to transfer to SP's Peninsula train service at San Jose is estimated to be 3,000 in 1990.

Figure 36 graphically illustrates the ridership levels achieved in each of the five transit study corridors in 1990 assuming the light rail alternative.

Transportation Service Effectiveness to Major Activity Centers

Table 20 presents the forecast 1990 peak-period home-work trip modal splits for various Santa Clara County major activity centers assuming a light rail or busway transit system were operating then in the five study corridors. The highest volume of transit trips (6,050) as well as the highest percentage modal split (28 percent) would be attracted to the San Jose central business district. Roughly one-third of all 1990 transitway riders would be destined for here, another one-third

would transfer to the SP's Peninsula route for destinations in Santa Clara, Sunnyvale, Mountain View, and Palo Alto, and the remaining one-third would be distributed to activity centers located along the five transitway corridors in Cupertino, Campbell and San Jose. Note that most of these "suburban" employment areas/activity centers would attract between 5 and 10 percent of the peak-period travel market to transit, the higher transit modal splits being achieved by those areas experiencing the higher traffic congestion levels.

Table 20
1990 PEAK-PERIOD TRANSITWAY MODAL SPLIT FOR SELECTED MAJOR ACTIVITY CENTERS -- HOME-WORK TRIPS

Activity Center	Transitway Trips	Total Transit	Modal Split (Percent)
San Jose CBD	5,650	6,050	28.0
San Jose Civic Center	125	800	10.0
Pruneyard-Campbell CBD	50	150	5.0
De Anza College-WV Business Park	120	170	8.0
General Electric Area	850	1,020	9.0
Almaden Plaza/Oakride Mall	150	350	7.0
IBM Area	250	350	7.0
(Countywide)	(17,000)	(36,000)	(7.8)

Results of Sensitivity Testing

The sensitivity tests reported on in Working Paper No. 5 showed that several key factors/basic assumptions could influence transitway ridership greatly, while others would do so much less markedly. Figure 37 presents a listing and relative ranking of the nine key factors which are felt to influence future transitway ridership forecasts the most in Santa Clara County.

The two key factors which emerged as holding the most leverage over transitway ridership using the best available forecasting relationships were auto operating costs and average travel speeds. When auto operating costs were raised 65 percent by assuming $1.00 per gallon for gasoline and a 50 cents per day parking charge at all major employment centers, transit patronage almost tripled. Similarly, when one compares the low 1975 transitway ridership forecasts with that for 1990, it can be seen that transitway ridership grew by a factor of 2.75. New population and employment growth can explain only about half of this increase; the remaining 40 percent-plus gain was caused by a 20 percent decrease in the average peak-period auto speeds in 1990. More on the significance of increasing auto congestion/decreasing auto speeds is presented below. However, it should be made clear that if the Guadalupe and West Valley freeways were to be built and I-280 and US 101-Bayshore Highway widened to eight lanes, then transitway ridership could be expected to drop to about 60 percent of the level shown elsewhere in this report for the "Base Case" transitway alternatives.

Today in Santa Clara County, buses travel on wide, high-speed arterial streets and make stops about every 1/4 to 1/3 mile on the average. This accounts for their relatively high average travel speeds when compared with that of other urban areas. Buses traveling the routes today in the five study corridors average over 17 MPH, with routes on the Almaden Expressway and Monterey Highway averaging around 20 MPH.

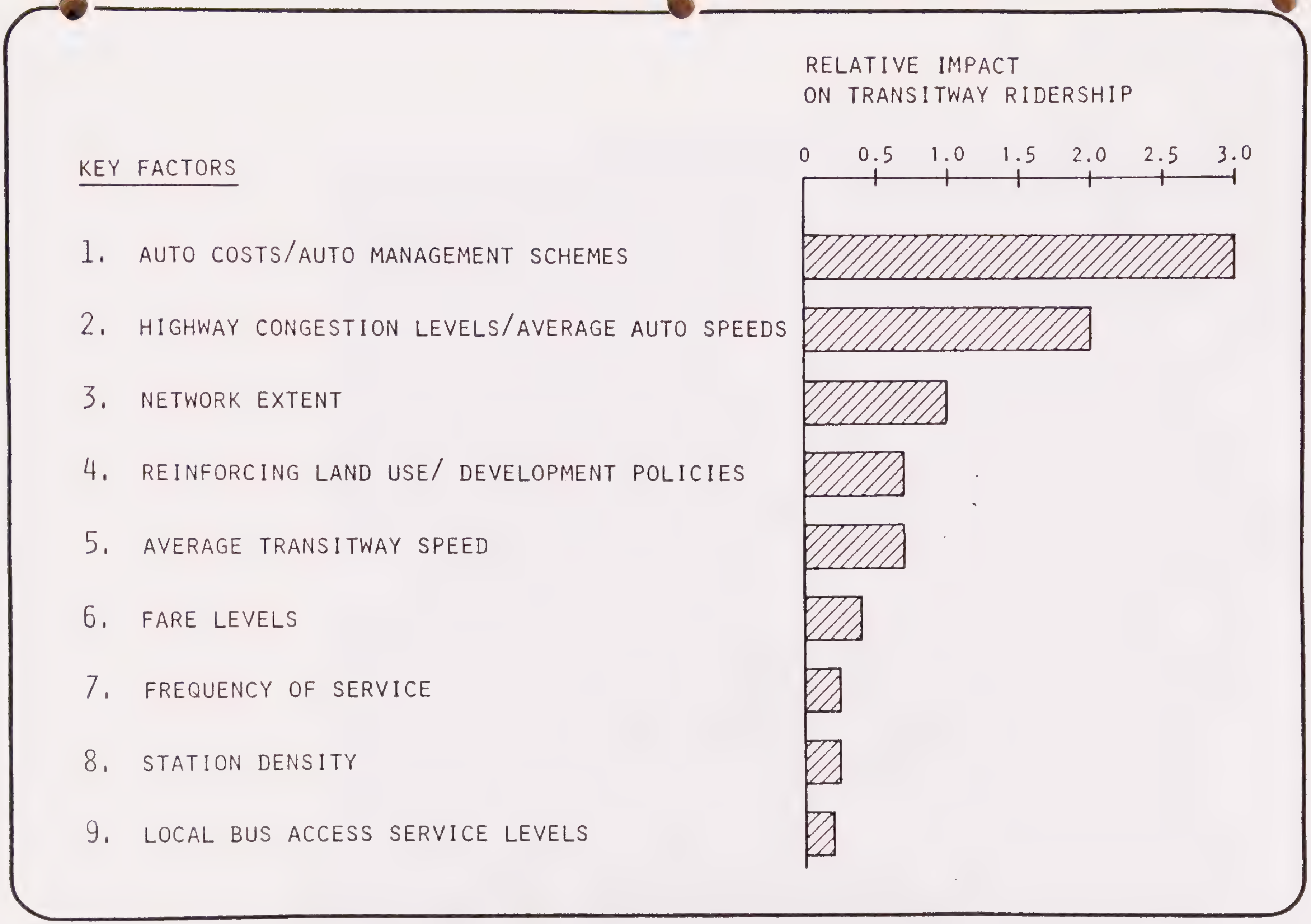

Figure 37
RELATIVE RANKING OF KEY FACTORS INFLUENCING TRANSITWAY RIDERSHIP

Peak-period congestion does not lower schedule speeds by more than 2 to 3 MPH from the free-flowing schedule speeds. However, as traffic congestion progressively worsens and additional buses are added to these corridors, including some skip-stop or express routes, both the need and the advantages of bus preferential treatments/reserved transitway facilities will become clearer.

Local arterial-route buses will still be using the Santa Clara County street system in 1990, and thus will be subject to all of the congestion and delays forecast for the automobile system on these same facilities, unless of course, reserved lanes and signal preemption are installed by then. Even so, the traffic congestion on side streets, parallel streets, and in the central areas will have a telling effect on today's high average bus speeds, perhaps cutting them by as much as half to the 8 to 10 MPH range in peak periods commonly found today in other metropolitan areas.

For the typical 7- to 8-mile long work trip made in Santa Clara County, it is estimated to require 40 to 45 minutes to make today by local bus (five minute walk to bus stop, five to ten minute wait for bus, seven-mile ride on bus at 17 MPH average, and a three to five minute walk from the bus to one's final destination). This is about twice as long as the typical work trip in an automobile now takes. If bus speeds are degraded along with the automobile's by 1990 so that buses would then operate in the 8 to 10 MPH range, the same trip by bus would take about 60 to 75 minutes to complete. This again is about double the travel time projected for the automobile in 1990.

If a light rail or bus transitway were built in the five study corridors, a typical 7- to 8-mile long County work trip might require a ten to fifteen minute auto or bus access time, a four-minute wait for a guideway vehicle, a seven-mile transit ride at 30 MPH, and a three to five minute walk to one's final destination, for a total trip travel time of 30 to 40 minutes. This would represent a five to ten minute savings over today's bus travel times. When compared with today's auto travel times, the trip

by transitway would require an additional 12 to 18 minutes to make, or about 1.7 times more travel time. By 1990, however, the transitway travel time may equal or even be lower than the total auto travel time for many peak-period trips. Thus, while today's high auto and bus speeds do not show any major advantages in terms of travel times for a transitway in the study corridors, by 1990 rather severe traffic congestion is expected to occur which would radically alter the travel time ratios between the transitway and the automobile, and between the transitway and the local bus system.

Another sensitivity test showed that for every one percent addition to the transitway's network size (miles), the transitway's ridership could be expected to increase by approximately one percent. Specifically, a sensitivity test was run which increased the network size from 35 miles to 100 miles, an increase of 190 percent. A corresponding 190 percent increase in transitway patronage was recorded. Obviously, some additional network miles would increase patronage more than others because of their strategic location, and thus the more cost-effective network miles should be identified and built first.

Reinforcing land use/development policies around station sites which would encourage transitway usage were also shown to have a significant impact. From sensitivity tests performed on Santa Clara County's five study corridors, it can be implied that approximately a 0.7 percent increase in daily transitway ridership would result from each one percent increase in the presently-allowed development densities averaged over the entire area within one-half mile of the transitway station/stops.

In the specific sensitivity case tested, a 100 percent increase in the presently permitted densities was assumed for all vacant parcels of land within one-half mile of all 40 station/stops on the transitway system. The net result was an increase in the average density for the entire station/stop area of about 25 percent. Patronage tests showed that transitway ridership would be expected to go up by 18 percent.

Transitway ridership was shown to be only slightly less sensitive to the average transitway speed achieved. Tests showed that a one percent change in average operating speed would result in a 0.7 percent change in patronage. Specific tests were made assuming the transitway average speed was 25, 30, and 40 MPH.

Fares proved to have significantly less impact on transitway ridership than the five previously described factors. For every one percent increase or decrease in the base fare charged, transitway ridership would decrease or increase by about 0.4 percent. Specific tests were made assuming the base fare was 25, 35, 50 and 75 cents.

The frequency of service offered on the transitway was not specifically tested for this project. However, it was tested in RTDP Phase One, and in other transit patronage sensitivity tests for Denver and Los Angeles with comparable results. It can be expected that for each one percent increase in service frequency, transitway ridership would rise 0.25 percent.

Range of Peak-Hour Volumes Forecast and Ranking of the Five Transitway Corridors

Based on all of the different sensitivity tests and different land use development levels, it was possible to develop a range of patronage which could be expected on each of the transitway study corridors. These figures are presented below in Table 21 and represent a reasonable high and a reasonable low ridership expectation level. The actual ridership which would be experienced probably lies somewhere between these extreme levels. The results of the test of a 65 percent increase in the perceived costs of operating an automobile was felt to represent an extreme case and was excluded from this presentation.

As can be seen in Table 21, none of the five corridors would succeed in capturing more than 1,000 persons per hour in 1975, which closely approximates current conditions in 1976. The corridor consistently

achieving the highest ridership volume is the Guadalupe/Monterey Highway/Lick line, shown to attract between 2,500 and 7,200 peak-hour riders in 1990. The "Base Case" ridership volume estimate for this corridor is 4,450 per hour, assuming the entire 35-mile system were built, and 3,900 per hour if this line stood alone. The alternate alignment choice which would serve approximately the same corridor is the Fourth Street/Monterey Highway/Lick line, which was forecast to attract about 15 percent fewer riders.

Table 21
RANGE OF PEAK-HOUR TRANSIT VOLUMES FORECAST FROM SENSITIVITY TESTS

Transitway Corridor	1975	1990 Low	1990 Base	1990 High
1) De Anza Branch, WVTC	400	600	1,000	3,800
2) Blossom Hill Branch, WVTC	400	500	1,000	2,000
3) Vasona Branch-Winchester	900	1,200	2,300	2,500
4) Guadalupe/Monterey/Lick	1,000	2,500	4,450	7,200
5) Fourth Street/Monterey/Lick Alternate	900	2,200	3,900	6,400
Total Transitway Network	3,700	7,500	10,000	12,500
Total Transit System Including Local Buses	12,500	18,000	21,500	23,500
Approximate Daily Transit Ridership and Percentage Modal Split	100,000 (2.2%)	135,000 (2.2%)	160,000 (2.7%)	170,000 (2.8%)

None of the other three corridors approached the ridership achievement level of these first two alternates (only one of these first two transitway alignments would be built). The Vasona-Winchester corridor performed about equally as well as these first two in 1975, but failed to register the significant jump experienced by the first two corridors in 1990, capturing a maximum of only 2,500 riders per hour then. Both branches of the West Valley Transportation Corridor remained far behind both the 1975 and 1990 ridership forecasts for the three radial transitway corridor, with one exception. The "high" volumes shown for these two branches of the WVTC occurred only when a transitway connection was provided from De Anza College to the Palo Alto, Mountain View and Sunnyvale industrial park areas. Without this connecting line(s), ridership volumes on these two WVTC branches would remain under 1,500 riders per hour in 1990.

Systemwide ridership totals are shown at the bottom of Table 21. For the "Base Case" light rail system, 10,000 peak-hour riders were forecast for 1990. A high-low range of 12,500-7,500 riders shows that this "Base Case" ridership estimate should be within ± 25 percent of what would be expected to actually occur in 1990 under a wide range of varying assumptions.

Ridership for the total transit system is far less elastic due to the more or less constant local bus patronage which accounts for from 50 to 60 percent of all transit ridership in this study under a wide range of assumptions. The "Base Case" peak-hour transit total is 21,500, while the high-low figures range from 23,500 to 18,000, a difference of about ± 17 percent. The daily transit ridership totals for 1990 range from 135,000 to 170,000, a ± 15 percent deviation from the "Base Case" estimate of 160,000. Compared with 1975 transitway-plus-local-bus patronage levels, those for 1990 would be about 40 to 80 percent higher. The daily modal split for the 1990 transitway system would range between a high of 2.8 percent to a low of 2.2 percent.

Comparison of Transitway Corridor Volumes With Those Experienced On Other Systems

To further put these potential travel market volumes for the five study corridors in perspective, it is worth examining how they compare with the ridership levels now being carried on existing light rail and busway transit systems elsewhere. Table 22 presents a survey of the approximate peak-hour and daily ridership volumes now carried or projected to be carried on seven representative busway transit systems around the world. Table 23 presents similar information for seven light rail systems now in operation or under construction.

As can be noted from the two tables, both busways and light rail operate in similar volume ranges, typically carrying between 2,500 and 10,000 passengers per hour in the peak periods and 15,000 to 50,000 passengers daily. Light rail transit systems generally carry over 5,000 passengers per hour past the peak load point in the system, which appears to run about double the peak-hour volumes (2,500) carried on most busway facilities. Edmonton, Canada, is now building the initial 4-1/2-mile segment of its light rail system, which is initially estimated to carry 5,000 passengers per hour when it opens in 1978. The 34-mile Tyne and Wear LRT system now being built in Newcastle, England, largely in existing railroad rights-of-way, is planned to carry between 5,000 and 9,000 passengers per hour on the peak load points of its various branches. Amsterdam, with an already extensive 100-mile light rail network, has a policy of converting bus routes to light rail lines when route patronage exceeds 15,000 riders per day, or about 3,000 per peak hour.

The study corridor exhibiting the highest travel market potential is the Guadalupe/Monterey Highway/Lick line, which is estimated to carry about 1,000 riders per hour in 1975 and 4,500 per hour (29,000 daily) in 1990 past the peak load points. These volumes also assume that the entire 35-mile system is built and that an upgraded Southern Pacific Peninsula service is accessible via a convenient transfer. If the Guadalupe/Monterey Highway/Lick line alone were to be built, then the number of

Table 22
SURVEY OF RIDERSHIP VOLUMES ON REPRESENTATIVE BUSWAY SYSTEMS

	Number of Passengers Carried	
	Peak Hour	Daily
Los Angeles-San Bernardino Freeway*	2,900	15,000
Washington, D.C. - Shirley Highway**	6,200	25,000
Pittsburgh (Planned) East PATway**	7,500	37,400
South PATway	5,400	27,700
Milwaukee (Planned)**	3-4,000	
Kansas City (Planned)**	2,700	14,500
Dayton, Ohio (Planned)**	2,200	15,000
Boston-SE Expressway** Peak-Period Contra-flow Lane	2,450	6,000

* Source: SCRTD, 1975

** Source: National Cooperative Highway Research Program Report No. 143, Bus Use of Highways: State of the Art. 1973.

Table 23
SURVEY OF RIDERSHIP VOLUMES ON REPRESENTATIVE LIGHT RAIL SYSTEMS

	Number of Passengers Carried	
	Peak Hour	Daily
San Francisco Muni*	10,000	100,000
Pittsburgh*	8-9,000	25,000
Philadelphia*	5,000	25,000
Toronto, Canada*	5,600	28,000
Shaker Heights, Cleveland*	3,500	16,000
Edmonton, Canada**	5,000	25,000
Tyne and Wear, Newcastle, England***	5-9,000	25-45,000

* Source: Lea Compendium for Light Rail, Volume II, No. 5, 1975

** Source: Information provided by the City of Edmonton Rapid Transit Division

*** Source: "Tyneside Rapid Transit Analysis - Technical Report." AM Voorhees and Associates, June 1972.

trips would be reduced to about 3,900 per hour (25,000 daily). The alternate alignment choice serving this corridor would exchange the Guadalupe freeway right-of-way alignment through Willow Glen for the Fourth Street SP Railroad right-of-way through a heavy industrial area, and would attract about 15 percent fewer peak-hour riders (3,400 versus 3,900).

TRANSPORTATION SYSTEM IMPACTS

Impacts on Parallel Highway Volumes and Speeds

Table 24 indicates the order-of-magnitude impact of the five-corridor transitway system on the volume and speed of highway traffic paralleling the designated transit corridors. Between 10 and 20 percent of 1990 AM peak period home-based work travel in the designated corridors is expected to use the transitway. Based on computer simulation of 1990 travel patterns, assuming no new freeway construction and the county land use assumptions developed in RTDP Phase One, maximum transit mode choice would occur in the Monterey Highway and Guadalupe corridors, while minimum transit mode choice would occur in the West Valley corridor. Highest transit ridership is projected for the Bayshore/SPRR corridor with Monterey Highway, Vasona and Guadalupe corridors following in descending order.

The average peak hour vehicle speeds along the designated corridors could be expected to improve on the order of 5 to 10 MPH with transitway implementation. In each case, highway speeds without a transitway would be subcritical (i.e., stop-and-go, Level of Service "F"), while speeds with a transitway would improve to a congested Level of Service "E".

Table 24
IMPACTS ON PARALLEL HIGHWAY VOLUMES AND SPEEDS (Peak-Period Home-Based Work Trips)

Highway Corridor and Parallel Transitway	1990 AM Peak-Period Highway Demand Auto Trips	1990 AM Peak-Period Transit Riders	Consequent Reduction in Auto Highway Demand	Approximate Avg. Highway Speed W/O Transitways*	Approximate Avg. Highway Speed W/ Transitways*
De Anza Branch West Valley Corridor	6,000	1,500	900 (15%)	15-25	20-30
Blossom Hill Branch, West Valley Corridor	3,500	1,500	500 (15%)	15-25	20-30
Vasona/ Highway 17	14,000	3,200	1,700 (12%)	10-20	15-25
Monterey Hwy/ US 101 Frwy Corridor	17,000	3,600	2,600 (15%)	5-15	15-25
Guadalupe/ Almaden Expwy Corridor	9,000	2,900	1,500 (17%)	5-15	15-25
SPRR/Bayshore/ I-280	32,500	5,000	3,600 (11%)	10-20	15-25

*Order-of-magnitude speeds only; based on April, 1976 computer simulation of 1990 AM peak period, home-based work travel; assumes no new freeway construction and modified "Trends 3" 1990 land use assumptions. Home-based work travel constitutes approximately 75% of the total AM peak-period trips.

Impacts on Intersecting Cross-Traffic

At midblock transitway grade crossings, delays will occur due to the installation of new traffic signals; this delay could be as long as 15 seconds for every crossing transit vehicle. At intersection grade crossings, additional traffic delays will occur, from 10 to 25 seconds for every crossing transit vehicle.

Where the transitway alignment is in the median of a street, such as is the case on Branham Lane and Monterey Highway, local traffic circulation will be disrupted somewhat and will take time to readjust to new travel patterns.

Between five and ten minor street closures due to transitway implementation would have little effect on traffic circulation because these streets carry local traffic only and alternate access routes exist.

Station Parking Requirements and Traffic Impacts

Table 25 presents the estimated reductions in parking space requirements at major activity centers attributable to the five-corridor transitway system:

Table 25
REDUCTION IN PARKING SPACE REQUIREMENTS OF MAJOR ACTIVITY CENTERS

Activity Center	Parking Space Reduction
San Jose CBD	5,000
San Jose Civic Center	1,000
Pruneyard-Campbell CBD	300
General Electric Area	500
IBM Area	1,500
De Anza-West Valley Business Park	250
Oakridge Mall Area	150
Almaden Fashion Plaza Area	250

The total reduction in parking space requirements at activity and employment centers around the County is estimated to be 17,000 in 1990 as a result of full implementation of the five-corridor transitway system.

Approximately 40 stations/stops will require construction of some 12,000 new parking spaces, or an average of 300 spaces per stop, leaving a net reduction in County-wide parking spaces required of 5,000. Almost all stations/stops will require between 200 and 300 spaces. A few stations/stops will require major parking lots as listed in Table 26.

Table 26
PARKING REQUIREMENTS AT MAJOR TRANSITWAY STATIONS/STOPS

Stations/Stops	Required Parking Spaces
Vasona Junction	600
Fruitdale Avenue	500
Camden Avenue	500
Almaden Plaza	500
Oakridge Mall	1,200
IBM/Santa Teresa	1,500
Chynoweth	500
Branham Lane	600
Capitol/Senter Road	500
Curtner/Canoas Garden	500

At each station/stop with parking, there will be a noticeable increase in traffic at the entrance to the parking lot and possibly on nearby streets. Station/stop area traffic impacts on traffic congestion will be roughly proportionate to parking lot size. At stations without parking, there will be an increase in pedestrian and feeder bus activity which could slightly affect traffic. Both types of stations would also attract "kiss and ride" auto traffic which would further affect circulation in the vicinity of stations.

County Bus System Impacts

County bus system patronage including transfer riders is expected to be 25 percent greater with the five-corridor system than without the transitways. This is based on a 516-vehicle bus fleet which provides an estimated daily ridership in 1990 of 120,000 for baseline bus and 150,000 for the five-corridor transitway system (50,000 feeder bus rides plus 100,000 bus-only rides). An average of 280 daily riders per bus would be carried aboard the baseline system versus an average 350 daily riders per bus for the network supporting the transitway plan. Minor modification of the County's bus system routing is required to complement the transitway system.

Impact on Southern Pacific Ridership

Given the assumptions made regarding service improvement, ease and cost of transferring, daily Southern Pacific ridership originating in Santa Clara County would increase dramatically as a result of the five-corridor transitway system. For the entire County today's patronage of about 8,500 riders daily is projected to jump to around 25,500 in 1990 assuming the full, five-corridor transitway development -- a 200 percent increase.

Morning peak period boardings at the San Jose depot would increase from today's 900 to 5,000 in 1990 with full transitway development -- a 450 percent increase. It should be noted that present capacity of 7,500 seats (11 trains) leaving the San Jose depot between 6 AM and 8 AM is poorly utilized. Trains do not fill up until in northern San Mateo County and much available capacity exists for utilization in Santa Clara and southern San Mateo Counties.

The Southern Pacific Transportation Company would most likely have to be reimbursed by the Santa Clara County Transit District in order for transferring riders to avoid prohibitive fares.

The on-going Peninsula Transit Alternatives Study (PENTAP) sponsored by the Metropolitan Transportation Commission is now analyzing the alternatives of upgrading the existing Southern Pacific passenger service, constructing a BART extension, and providing express bus service in the San Jose to San Francisco corridor. PENTAP is expected to provide further insights into the potential for increased ridership in the SP's Peninsula corridor.

ACCESSIBILITY/MOBILITY MEASURES

The concept of accessibility/mobility includes considerations ranging from reduction of transit travel time and expansion of the number of possible destinations (opportunities) which can be reached within a reasonable transit travel time (say 30 minutes) to micro-scale station and vehicle design to accommodate the handicapped. Also, there is the concern to maximize station walk-in opportunities, i.e., people living within one-quarter mile of stations and jobs within one-half mile of stations. Although the focus of accessibility/mobility analyses is usually on transit dependents, i.e., the elderly, poor, youth and others unable to drive, one must also consider the impact on the general population who may choose transit in order to reduce their travel costs, conserve energy, or for whatever reason.

Access to Population and Employment

The map shown in Figure 38 illustrates the areas which would be within walking distance (one-quarter mile) of a transitway station or stop. A total of 40 stations/stops were established at roughly 0.8-mile intervals along the 35 miles of study corridors. These were located to serve major activity centers and to provide convenient transfer points for bus and auto users. A physical inspection of the corridors and a look at the 1975 aerial photos show that the area surrounding about 15 of these 40 potential sites is occupied solely by residential uses (mostly single-family dwelling units); the area surrounding another 20 sites is occupied by a mix of land uses, approximately half of which is residential;

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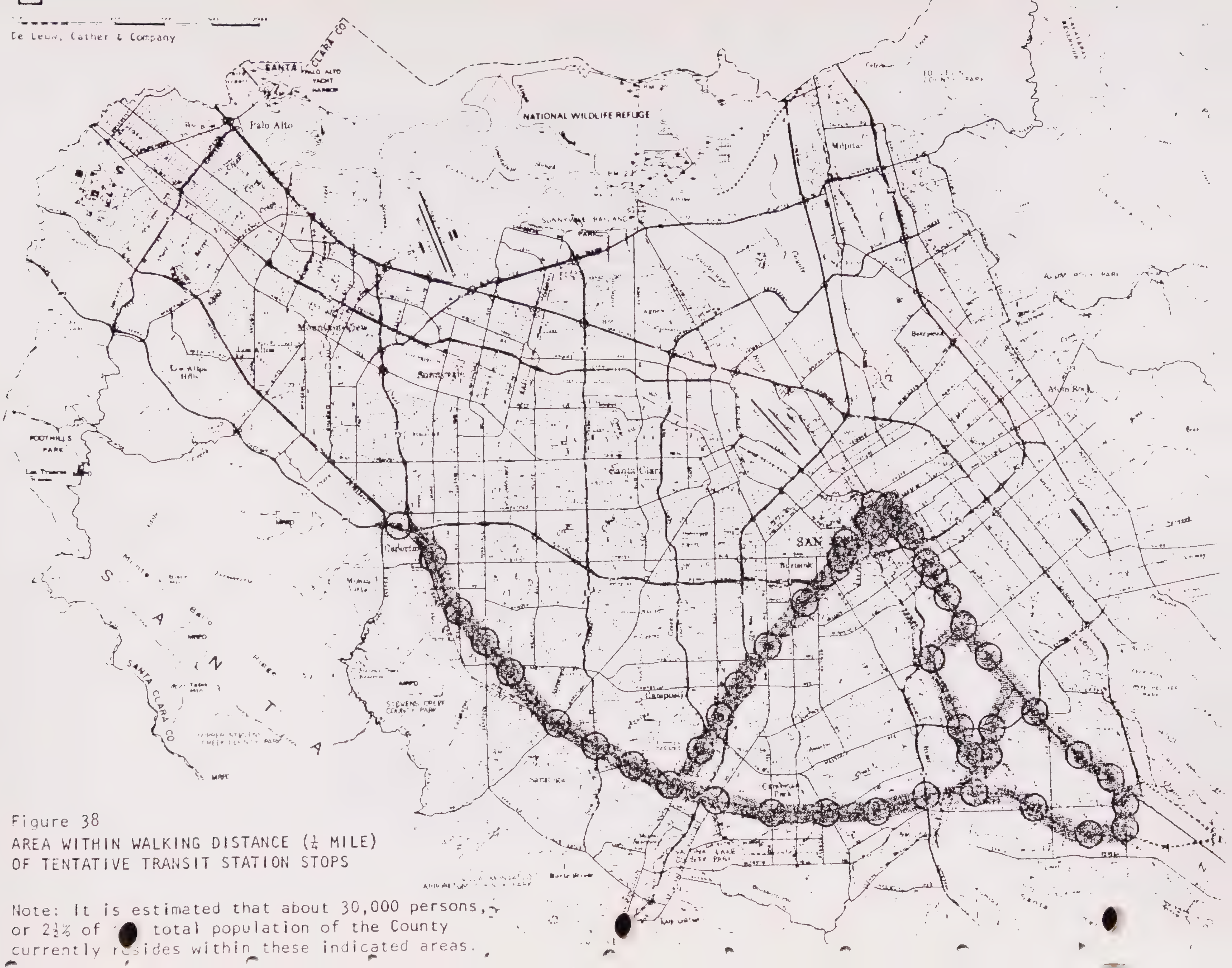

Figure 38
AREA WITHIN WALKING DISTANCE ($\frac{1}{4}$ MILE)
OF TENTATIVE TRANSIT STATION STOPS

Note: It is estimated that about 30,000 persons, or 2½% of the total population of the County currently resides within these indicated areas.

and the remaining five sites are presently surrounded by vacant land. Adding up all of the residential land which is within one-quarter mile of the 40 potential transit stations/stops within these five study corridors, a total of about five square miles is arrived at out of a total potential area of eight square miles.

The current population density within the urbanized area of Santa Clara County varies between 2,500 and 10,000 persons per square mile, with an average of about 6,000 per square mile for developed residential land. This would indicate that relatively few people -- somewhere around 30,000 assuming average densities -- would be able to walk from their homes to a light rail or busway transit station/stop. If major public policy incentives were implemented so as to restructure growth around transit station/stop sites in higher density cluster developments, perhaps this walk-in number could be doubled. But even so, less than five percent of the County's residents would live within walking distance of a transitway station/stop in these five study corridors; the great majority of the population would have to either ride a bicycle or a local county bus, or drive an automobile to the nearest station/stop in order to make use of a transitway system.

Figure 39 depicts a map illustrating the area lying within one and one-half miles on either side of a transitway station/stop in the five study corridors. The one and one-half mile distance represents about an eight-to-ten minute bicycle or local bus ride and a short five-to-seven minute auto drive to the nearest transit station/stop. The distances people are willing to travel to and from a line-haul transit system is a function of a number of things, including total trip length and the quality of service offered on the line-haul portion. This three-mile wide "catchment area" is judged to be reasonable for the current study.

Thus, an area within a three-mile wide band can be visualized along approximately 35 miles of corridor. Subtracting about 7 miles of corridor where overlaps occur, an area three miles wide by 28 miles long can be generated, encompassing some 84 square miles. Again assuming an

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Figure 39
AREA WITHIN 1½ MILES OF
TENTATIVE TRANSIT STATIONS / STOPS

Note: It is estimated that up to about 500,000 persons,
or some 4[illegible] of the total polulation of the County
[illegible]

average population density figure of about 6,000 persons per square mile, a population of approximately 500,000 persons would be served in the five study corridors, assuming auto, bus and bicycle modes are used to reach the stations/stops. This figure represents approximately 40 percent of Santa Clara County's 1,200,000 resident population today.

The map shown in Figure 40 illustrates the location of all major employers (generally those with over 500 employees) which would be accessible via either the five transit study corridors or via the corridors and a transfer to Southern Pacific's Peninsula service. Two major employment areas would be served directly by the five study corridors -- downtown San Jose and IBM at Cottle Road. Other important employment areas which would be served are the De Anza College/West Valley Business Park in Cupertino, downtown Campbell and the Pruneyard Towers in Campbell, General Electric and Stauffer Chemical companies in San Jose, the San Jose Civic Center complex (via bus transfer), and the Almaden Fashion Plaza/Oakridge Mall area in south San Jose. However, all of these jobs which would be accessible via the five study corridors account for fewer than 50,000 jobs, or less than 10 percent of the County's total estimated 1975 employment of 500,000.

Looking at the number of major employers and jobs lying along Southern Pacific's Peninsula route between San Jose and Palo Alto shown in Figure 40, one quickly becomes aware of the major importance of this corridor to any transit system serving Santa Clara County's work trips. Major employment areas accessible via the Southern Pacific's Peninsula route include downtown San Jose; FMC Industries in Santa Clara; the San Tomas Industrial Park in Santa Clara including Memorex; the Oakmead Industrial Park which is now under development on the Santa Clara-Sunnyvale border; Westinghouse, Western Electric, Signetics and United Technology in Sunnyvale; Fairchild Semiconductor in Mountain View; and Philco-Ford, Stanford, Stanford Industrial Park and the downtown business district in Palo Alto. All of these areas total up to over 80,000 jobs, or 16 percent of the County's 1975 employment base.

Figure 40
LOCATION OF MAJOR EMPLOYERS WITHIN 1 MILE OF THE STUDY CORRIDORS AND SO. PACIFIC COMMUTER R.R. LINE

Source: DOT Telephone Survey, 1976

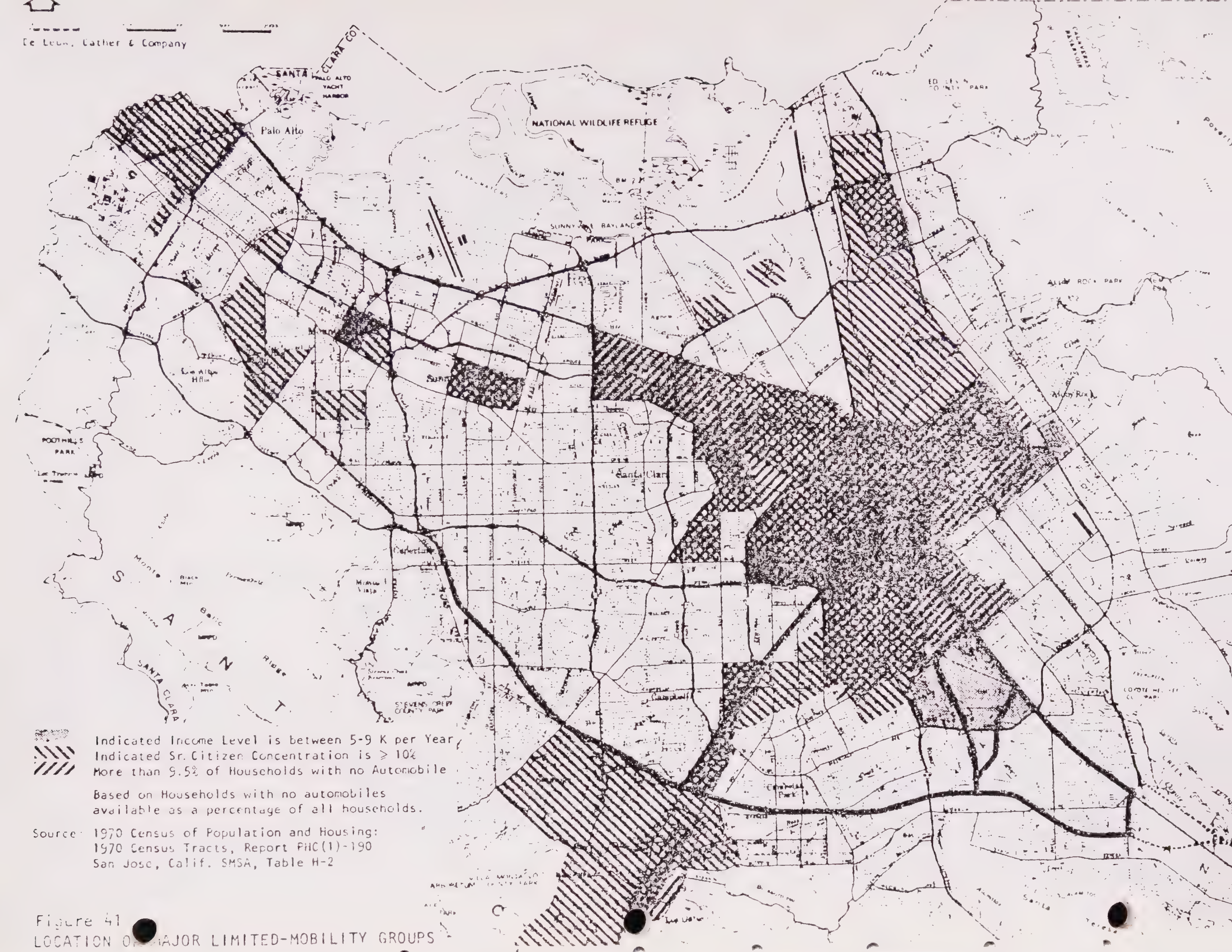
Assuming some form of transitway were implemented in the five study corridors and that a convenient transfer arrangement to Southern Pacific's Peninsula service could be worked out, about 25 percent of the County's jobs would be accessible.

Access To Transit Dependents

Accessibility/mobility for transit dependents and the general population should be enhanced by faster speeds on exclusive guideway and grade-separated facilities assuming a feeder bus complement. Buses operating in mixed traffic over local streets will have lower accessibility values. Large scale transit facilities generally contain more accommodation for the handicapped (e.g., elevators, wide doors).

Figure 41 illustrates the location of limited mobility groups which would particularly benefit from transit including: lower income (with household incomes less than $9,000); elderly (over 62 years of age); and households not owning an auto. The baseline bus network which would serve as a feeder bus system to the transitway alternatives would extend accessibility benefits to limited mobility groups not located within walking distance of transitways.

Destinations of special interest to transit dependent groups include employment, cultural resources and shopping. An increasing number of new employment opportunities are predicted to open up in south San Jose near IBM -- the terminus of several of the transit corridors. Increased access to employment should improve the likelihood of matching skills with employment requirements. Similarly, industrial and commercial establishments will benefit by being able to draw upon a larger work force. The elderly should benefit greatly from the transit system primarily during off-peak hours to reach shopping centers, medical facilities, recreation and friends.



Indicated Income Level is between 5-9 K per Year
Indicated Sr. Citizen Concentration is ≥ 10%
More than 9.5% of Households with no Automobile

Based on Households with no automobiles available as a percentage of all households.

Source: 1970 Census of Population and Housing: 1970 Census Tracts, Report PHC(1)-190 San Jose, Calif. SMSA, Table H-2

Figure 41
LOCATION OF MAJOR LIMITED-MOBILITY GROUPS

Localized impacts due to increased accessibility must also be considered. Walk-in opportunities (employment, shopping, recreation) should be significantly enhanced by the station location, particularly if new development is concentrated in the station areas. On the other hand, some physical barriers could be created by transit facilities (e.g., transitway fencing) which limit pedestrian access across the transitway to schools, parks, or neighborhood stores.

Special provisions for the handicapped are required to be incorporated within the design of new rapid transit systems funded by UMTA. Rapid transit stations that are not at-grade must bs served by elevator to accommodate persons in wheelchairs, on crutches, or with other physical handicaps unable to negotiate stairways and escalators. Vehicle doors and seating arrangements must be configured to accommodate wheelchairs.

Access to Major Activity Centers

The following sections discuss the location of Santa Clara County's major activity centers such as colleges and universities, regional shopping centers and social and recreational areas with respect to the five designated study corridors.

As Figures 42 and 43 reveal, travel time to the San Jose CBD would be significantly reduced with the transitway alternatives versus a local bus system for residences within or adjacent to the study corridors; roughly doubling the percentage of regional population within 15 and 30 minutes travel time of this major service, cultural and employment center.

Five regional shopping centers are located in or near the five transit study corridors as shown in Figure 44. They are: Westgate/Paseo de Saratoga (one mile away); Pruneyard Towers (0.5 mile away); Almaden Fashion Plaza (with 1/4 mile walk); Oakridge Mall (within 1/4 mile walk); and downtown San Jose (all within 1/4 mile walk).

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— Bus routes in Study Corridors (Planned)
15 Minutes
30 Minutes

Figure 42
LOCAL BUS ROUTE ACCESSIBILITY -
CORRIDOR AREAS WITHIN 15 MINUTES AND 30 MINUTES
TRAVEL TIME FROM CENTRAL SAN JOSE

Figure 43
TRANSITWAY ACCESSIBILITY -
CORRIDOR AREAS WITHIN 15 MINUTES AND 30
MINUTES TRAVEL TIME FROM CENTRAL SAN JOSE

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Figure 44
LOCATION OF MAJOR REGIONAL SHOPPING CENTERS WITHIN 1 MILE OF STUDY CORRIDORS

Source: 1974-75 Shopping Center Guide

Two other regional shopping centers could be made more accessible to transit riders through minor modifications to Southern Pacific station locations. By moving the Castro station in Mountain View, which is now located at Rengstorff Avenue, 3/4 mile north to a site just south of San Antonio Road, three large shopping centers would become accessible -- San Antonio Plaza, the Old Mill and Mayfield Mall. A shuttle bus could connect all three to the transit station/stop near San Antonio Road. Likewise, a convenient shuttle bus service at the University Avenue station/stop in Palo Alto would make the Stanford Shopping Center area more transit-accessible to persons living along the study corridors.

The map in Figure 45 shows the location of the major institutions of higher learning which would be accessible by the five transit study corridors or via a transfer to Southern Pacific's Peninsula service. The two major colleges and universities which would be directly served by the five transit corridors are California State University at San Jose (San Jose State) and De Anza College. Located only a short distance away from the study corridors are West Valley College (Saratoga Campus) and San Jose City College (Moorpark Campus), which could be easily connected with a shuttle bus to nearby transit stations/stops.

Both Santa Clara University and Stanford University would be accessible via transfer to Southern Pacific. Thus, all three four-year universities and three out of five community colleges in Santa Clara County could be served by these five corridors and Southern Pacific's Peninsula route.

Numerous major social and recreational opportunities would be made accessible via transit running in the five study corridors, as shown in Figure 46. These include De Anza College and Flint Theatre, the Paul Masson Winery and Tasting Room, Vasona Lake and County Park, Frontier Village, the Santa Clara County Fairgrounds, San Jose State's Spartan Stadium and athletic fields, Kelly Park, San Jose State University and San Jose's new Community Theatre and Center for the Performing Arts. All of these areas receive over 100,000 visitors annually, while Vasona Park, the County Fairgrounds and Kelly Park each receive about one million visitors annually.

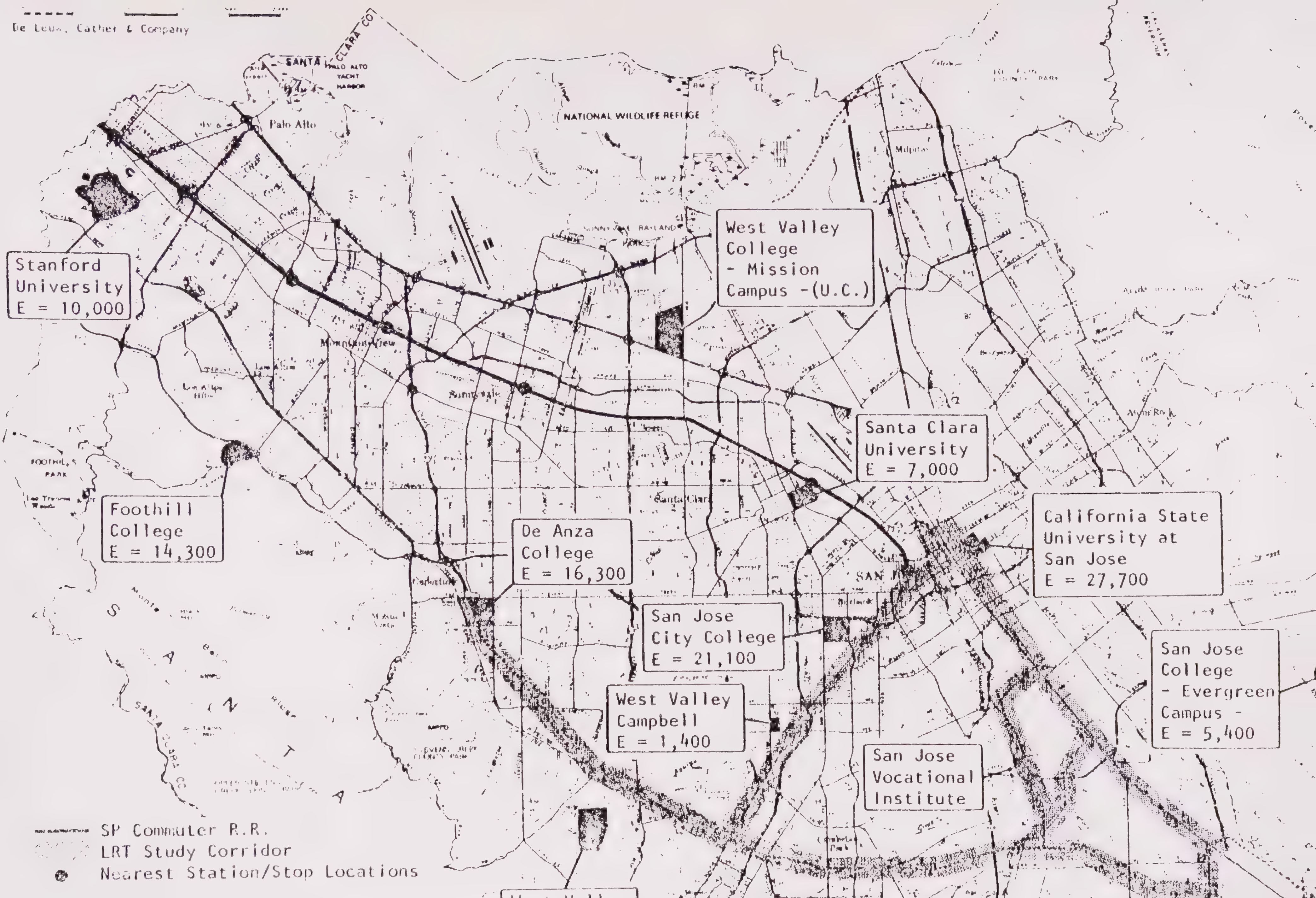

Figure 45
LOCATION OF MAJOR INSTITUTIONS
OF HIGHER LEARNING IN
SANTA CLARA COUNTY

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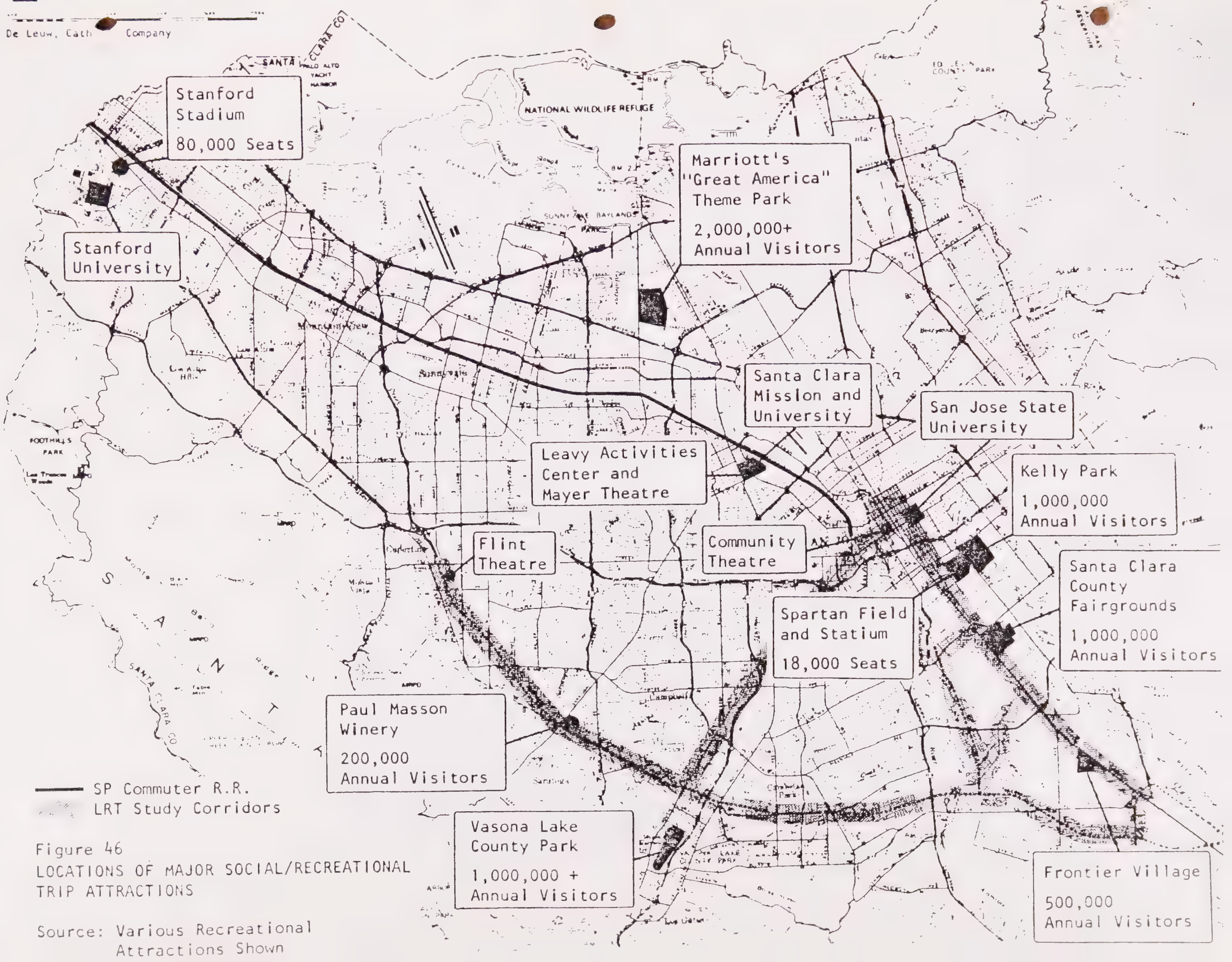

Figure 46
LOCATIONS OF MAJOR SOCIAL/RECREATIONAL TRIP ATTRACTIONS

Source: Various Recreational Attractions Shown

Also accessible via a transfer to Southern Pacific would be Santa Clara University and its associated activity centers, Marriott Corporation's "Great America" Theme Park (over two million annual visitors expected), and Stanford University and its associated activity centers. The Marriott and Stanford University areas would require shuttle bus connecting services in addition to Southern Pacific to make them accessible to transitway users.

CHAPTER VI

SYSTEM OPERATIONS, OPERATING COSTS AND FARE REVENUE ESTIMATES

SYSTEM OPERATIONS

This section of the report describes how the various transit alternatives could be operated, given the ridership forecasts and passenger line volumes presented previously. Operating patterns and strategies were developed which would balance the transit service levels supplied (measured in vehicles per hour) with the expected 1990 peak-hour transit ridership demands. Once the required transit headways (vehicles per hour) and routing strategies were determined, it was possible to calculate the required number of transit vehicles to service the 1990 peak-period demands. To this "active" fleet was added an appropriate number of vehicles for spares and repairs, resulting in a total fleet size estimate.

Once the peak-period active fleet size had been determined for the transit alternatives, it was possible to compute the "base" (midday) and "evening" (after 6 PM) headways required, assuming the District's current operating policy of a 30-minute maximum service headway and on the policy of ensuring everyone a seat during these two off-peak periods. On the express bus and transitway alternatives, these policy guidelines resulted in headways of roughly 12 to 15 minutes during the base period and 20 to 30 minutes during the evening period. Transit service was assumed to be provided 16 hours a day, from 6 AM to 10 PM, in accordance with current District operating policy. The definition of these operating periods and headway policies, together with the required fleet of transit vehicles to operate these service levels during each period of the day, led to calculation of the daily vehicle-hours and vehicle-miles required of each of the transit alternatives. These two daily operating parameters were then expanded to annual totals using an annualization factor of 286 equivalent weekdays of operation per year, in line with current District service level patterns on Saturdays and Sundays.

Annual operating costs could then be estimated based on the five operating cost parameters of system size (miles of track or bus lanes), number of stations/stops and parking lot spaces, number of transit vehicles, annual vehicle-hours and annual vehicle-miles. The estimated annual operating costs for each transit alternative are described and shown in the succeeding section. The individual operating patterns and fleet size requirements for each of the transit alternatives are discussed below.

Baseline Bus

Although exact operating schedules and runs have not yet been finalized pending the arrival and actual operating of the 300 additional buses, it is estimated that the annual vehicle-hours and vehicle-miles operated by these new buses will be at approximately the same rates experienced on the current bus operation, or about 2,700 vehicle-hours and 40,000 vehicle-miles per year per bus. Today's average bus operates roughly ten hours per day at 14.5 MPH. Projecting these same rates for the full 516-bus operation, the annual operating statistics would be approximately 1,475,000 vehicle-hours and 21,400,000 vehicle-miles. Compared with today's 236-bus operations, this represents about a 2.25 increase.

Increased Local Bus Service

This alternative builds on the Baseline Bus system using the same routes and type of local bus services, primarily running on arterial streets with stops every one-quarter to one-third mile. However, service frequency would be greatly increased from an average of one bus every 20 minutes during peak periods on the 46 routes to a bus every 10 minutes on these same routes. Consequently, the bus fleet requirements would be doubled from 516 to about 1,000.

Annual vehicle-hours and vehicle-miles operated by these additional 500 buses are expected to be about 20 percent lower than the existing 236-bus

system and planned 516-bus system rates due to less use during the off-peak periods. The added buses would all be used during peak periods, but cut back during midday and evening hours. As a result, the operating statistics which would be produced by these additional 500 buses are estimated to be 1,300,000 vehicle-hours and 18,900,000 vehicle-hours, which is about an 85 percent increase over the Baseline 516-bus alternative.

Bus Preferential Treatment

Figure 47 shows the required number of large, 70-seat articulated buses per hour necessary to carry the expected peak-period ridership demands. A total active fleet of 60 articulated buses would be required to service the five corridors operating at average speeds of 20 to 30 MPH, including stops about every mile and a half. With the addition of 12 spares and repairs, the total additional fleet required would be 72 articulated buses.

Headways in these five transit corridors would be on the order of three to five minutes during peak periods. During midday, these same routes would be cut back to one bus every 12 to 15 minutes, and during evening hours to one bus every 20 to 30 minutes, resulting in a need for 28 buses and 16 buses during these two service periods, respectively.

The addition of these bus preferential treatment routes and services would add about 163,000 bus vehicle-hours and 3,100,000 bus vehicle-miles to the District's annual operating statistics. The represents about a 11 percent increase in vehicle-hours and a 14.5 percent increase in vehicle-miles, as the new buses would be expected to average over 18 MPH, including stops and layovers.

In addition to the bus preferential lane reservations and signal pre-emption improvements, this transit alternative assumed that Southern Pacific's Peninsula route passenger train service would be upgraded

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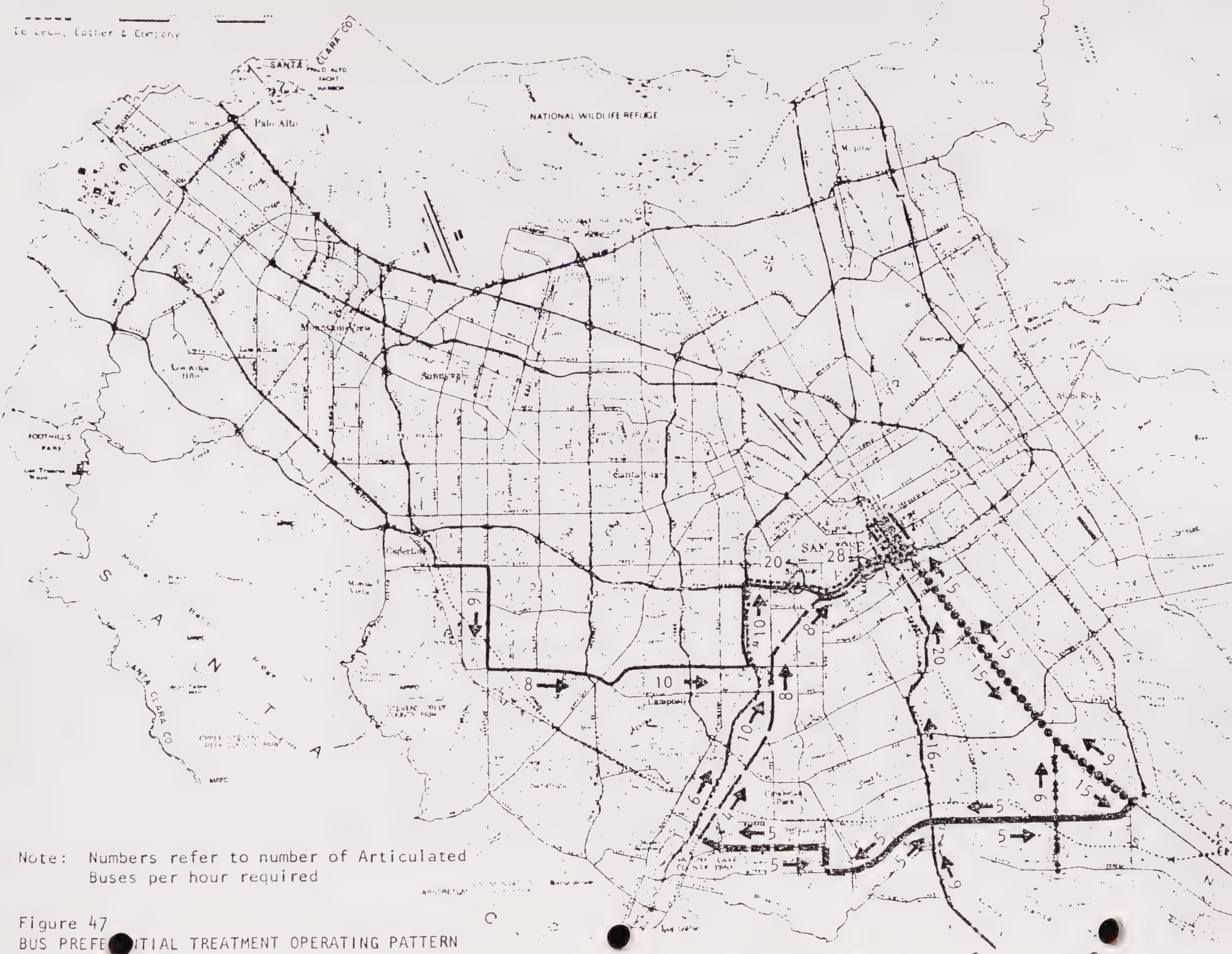

Note: Numbers refer to number of Articulated Buses per hour required

Figure 47
BUS PREFERENTIAL TREATMENT OPERATING PATTERN

and improved in Santa Clara County, and that the County Transit District's buses would provide quick and convenient "cross platform"-type transfers to SP trains at all of the train depots. It was further assumed that the Transit District would reach an agreement with Southern Pacific which would provide for a free transfer arrangement for County transit riders desiring to use the SP trains to complete part of their trip, and that County transit patrons arriving at the SP depot by car or walking would pay the same fare rate prevailing on the County Transit District's express transit services.

Busway Transit

Figure 48 illustrates the operating pattern selected for running the five-corridor busway system in 1990. Care was taken to balance service frequency and thus transit capacity with the expected passenger demand line volumes. As a result, a large 60-foot articulated bus with a 105-person carrying capacity would be required every six minutes during peak periods on both branches of the West Valley Transportation corridor, resulting in a bus every three minutes on the Vasona-Winchester corridor. The Almaden and IBM area branches would require large buses every five minutes and three minutes, respectively, resulting in a bus less than every two minutes on either the Guadalupe or Monterey Highway corridor where the two branches merge. The total active fleet required during peak periods on the busways would be 62 articulated buses. Adding spares and repairs at 18 percent of the active fleet (reflecting current practices), the total fleet required would come to about 75 articulated buses.

During the base or midday service period, headways on the outer branches would be cut back to 12 minutes, resulting in a six-minute service on both the Vasona and Guadalupe trunk lines. About 26 articulated buses would be required to provide a seat for every passenger and meet these headways. During the evening service period, busway service would be further curtailed to a bus every 20 minutes on the branches and every 10 minutes on the trunks. Only 15 articulated buses would be required to meet this service schedule.

Note: Numbers refer to number of Articualted Buses per hour required

Figure 48
BUSWAY TR SIT OPERATING PATTERN

As a result, the annual busway vehicle-hours and vehicle-miles generated would be 160,000 and 3,320,000 respectively. This represents a 10.8 percent increase in vehicle-hours and a 15.5 percent increase in vehicle-miles operated over the Baseline 516-bus system. Adjustments to these annual operating statistics for options to the Base Case Busway are shown in the table below. The "SP/PUC Requirements" option would not differ noticeably in operations from the "Base Case" option. The "lower cost" busway option would operate at slower average speeds but would also require fewer vehicles per hour because of the lower patronage levels achieved. The "higher cost" busway option would achieve somewhat higher average operating speeds but as a result would also be required to provide more vehicles per hour in order to carry the increased passenger demands projected.

Table 27
BUSWAY TRANSIT OPERATING REQUIREMENTS

Busway Transit Subalternatives	Fleet Size Required	Annual Vehicle-Hours Operated	Annual Vehicle-Miles Operated
Base Case	75	160,000	3,320,000
SP/PUC Requirements	75	160,000	3,320,000
Lower Cost	75	157,000	2,900,000
Higher Cost	75	150,000	4,100,000

As with the Bus Preferential Treatment Alternative, the Southern Pacific Peninsula train service is assumed to be improved and upgraded with a free and convenient transfer arrangement between County Transit District vehicles and SP trains for in-county transit trips.

Light Rail Transit

Figure 49 illustrates the operating pattern selected for running the five corridor light rail transit system in 1990. The number of light rail vehicles (LRVs) per hour on any one line was determined by the expected passenger line-load demands and a peak-hour loading standard of 175 passengers per LRV (68 seated, 107 standing). Service headway on both branches of the West Valley Transportation Corridor would be 8.5 minutes, resulting in a headway of every 4.3 minutes on the Vasona-Winchester trunk line. On the Almaden branch line, ten LRVs per hour would be required for a 6-minute headway, while on the IBM branch line, 13 LRVs per hour would be required for a 4.6-minute headway. Where these two branches join together (could be at either Lick Junction or Curtner Avenue), some 23 LRVs per hour would provide service every 2.6 minutes on the Guadalupe or Monterey Highway trunk line. The active fleet requirements to service the five-corridor network in 1990 would be 40 LRVs. Assuming a 12 percent spare and repair allotment, 45 LRVs would be the total fleet size required.

During the base or midday service period, headways on the outer branches would be cut back to 12 minutes, resulting in a 6-minute service on both the Vasona and the Guadalupe trunk lines. About 21 LRVs would be required to provide a seat for every person and meet these headways. During the evening service period, light rail service would be further curtailed to a vehicle every 20 minutes on the branches and every 10 minutes on the trunks. Only 13 LRVs would be required to provide this service.

As a result, the annual light rail vehicle-hours and vehicle-miles generated would be 115,000 and 2,700,000 respectively. This represents a 7.8 percent increase in vehicle-hours and a 12.6 percent increase in vehicle-miles operated over the Baseline 516-bus system.

Adjustments to these annual operating statistics for options to the Light Rail Transit Base Case are shown in Table 28. The "SP/PUC Requirements" option would not differ noticeably in operations from the Base

Note: Numbers refer to numbers of LRV's per hour required

Figure 49
LIGHT RAIL TRANSIT OPERATING PATTERN

Case option. The "lower cost" light rail option would employ single-unit, non-articulated LRVs the same size as the PCC car -- some 75 of these vehicles would be required to handle the same passenger loads as 45 articulated Boeing LRVs. This option would operate at slower average speeds but would also require fewer vehicles per hour due to the lower patronage levels achieved at these slower speeds. The "higher cost" light rail option would achieve somewhat higher average operating speeds, but would also be required to provide more vehicles per hour because of higher patronage levels achieved.

Table 28
LIGHT RAIL TRANSIT OPERATING REQUIREMENTS

Light Rail Transit Subalternative	Fleet Size Required	Annual Vehicle-Hours Operated	Annual Vehicle-Miles Operated
Base Case	45	115,000	2,700,000
SP/PUC Requirements	45	115,000	2,700,000
Lower Cost	75*	140,500	2,850,000
Higher Cost	45	100,000	3,000,000

*Single-unit, non-articulated, PCC-type vehicles 50 feet long.

As with the previous two transit alternatives, an improved Southern Pacific Peninsula passenger service and convenient transfer arrangement between the County's transit system and SP's trains are assumed as an integral element in the successful operation of the light rail system.

Summary

The following table summarizes the key operating statistics computed as a basis for estimating the annual operating costs for all of the "Base Case" transit alternatives. All of the transit alternatives to the Baseline assume the full 516-bus system operations with minor routing changes and schedule modifications where services would overlap or interconnect. Therefore, only the transit service additions to the Baseline Bus system appear under each transit alternative.

Table 29
SUMMARY OF ANNUAL OPERATING STATISTICS -- "BASE CASE"

Transit Alternative	Route Miles	Fleet Size	Annual VHT	Annual VMT
Baseline Bus*	1,300	516	1,475,000	21,400,000
Increased Local Bus	0	500	1,300,000	18,900,000
Bus Preferential Treatment	47	72	163,000	3,100,000
Busway Transit	34	75	160,000	3,320,000
Light Rail Transit	34	45	115,000	2,700,000

*Statistics for all other alternatives are in addition to those shown for Baseline Bus.

It should be kept in mind that these are felt to be reasonable estimates of one way in which each of the transit alternatives could be operated in an efficient manner to match the expected 1990 patronage demands. Any changes in the anticipated average operating speeds or operating strategies assumed, as well as schedule revisions arising out of union work rules or for other reasons, could result in changes to these fleet size requirements and annual operating statistic estimates.

ANNUAL OPERATING COSTS

The cost-effectiveness comparisons and economic analyses for the different transit alternatives are dependent on both annual operating costs and farebox revenues. Operating and maintenance (O & M) costs were developed for the various alternatives based, to the extent possible, on experience with similar systems elsewhere, updated to June 1976 cost levels, and adjusted to the specific conditions anticipated for Santa Clara County. Light rail O & M costs are based on comparative analyses using both analytical and empirical cost information obtained from past studies and observed costs in other cities operating light rail transit systems. Bus and busway O & M costs are based on data from current Santa Clara County Transit District operating experience and observed costs in other cities operating busways and express buses.

Basis for Operating Cost Estimates

There are a number of assumptions required to develop operating costs including: service levels, comfort standards, staffing requirements, hours of operation, peak-to-base ratios, station layout, fare collection method, security force requirements, and so on. Explicit or implicit assumptions concerning many of these items are required and emphasis was placed on consistent treatment of the various alternative transit systems under study so as to permit consistent comparisons among alternatives.

Operating costs are particularly sensitive to system operating characteristics such as annual vehicle-miles per vehicle, average operating speed, the average number of vehicles per train, and the number of vehicle-miles per track mile. Thus, a comparison of an estimated cost per vehicle-mile for Santa Clara County may vary significantly from that experienced in other cities. Differences in accounting practices also make it particularly difficult to analyze and compare cost information between different operating properties.

Operating costs are those which are necessary to operate and maintain the system. The major items of operating costs are maintenance of way and structures, maintenance of vehicles, costs of power and fuel, direct labor costs of providing transportation, and general and administrative overhead. These items generally conform to American transit industry accounting practices and are defined as follows:

- Maintenance of Way and Structures. This category includes the expense of maintaining fixed facilities such as roadbeds, tracks, yards, shops, stations, electrical overhead (catenary) system, power supply systems, vehicle control, communications, and signal preemption equipment, landscaping, lighting, fencing and parking lots. For the Bus Preferential Treatment alternative, operating costs related to placing traffic-control cones, signing and policing the reserved bus lanes are also included under this category.

- Maintenance of Vehicles. Includes expense of maintaining, inspecting, repairing and cleaning of vehicles. Includes both labor and parts.

- Power and Fuel. Includes the expense of providing traction power for propulsion of rail cars, fuel for buses, and the auxiliary power for station and parking lot illumination, etc.

- Transportation. Includes the wages of the train attendants, bus drivers, and other personnel and material directly associated with transit operations.

- General and Administrative. Includes the administrative personnel, required in such functions as accounting, purchasing, scheduling fare collection, personnel, etc. and costs such as insurance expenses including liability and property damage insurance, office supplies and other administrative expenses.

Table 31
ANNUAL OPERATING COSTS -- LIGHT RAIL AND BUSWAY SUB-ALTERNATIVES
(June 1976 Dollars)

Sub-Alternatives	Annual Vehicle-Miles Operated	Unit Cost (1976 $)	Annual Cost ($ Millions)
Light Rail Transit			
Base Case	2,700,000	$2.05	$5.53
SP/PUC Requirements	2,700,000	2.05	5.53
Lower Cost*	2,850,000	2.05	5.85
Higher Cost	3,000,000	2.00	6.00
Busway Transit			
Base Case	3,320,000	$2.20	$7.30
SP/PUC Requirements	3,320,000	2.20	7.30
Lower Cost	2,900,000	2.20	6.40
Higher Cost	4,100,000	1.90	7.82

*Assumes operation of single-unit LRV's similar in size to a PCC car.

Table 32
RESULTING ANNUAL OPERATING COSTS PER VEHICLE-HOUR AND PER VEHICLE-MILE TRAVELED

Transit Alternative	Annual Cost Per Vehicle-Hour	Annual Cost Per Vehicle-Mile
Baseline Bus	$26.00	$1.80
Increased Local Bus	26.00	1.80
Bus Preferential Treatment	56.36	3.00
Busway Transit	45.62	2.20
Light Rail Transit	48.10	2.05

Table 31 presents the estimated annual operating costs for the light rail and busway subalternatives -- "Meeting SP/PUC Requirements," "Lower Cost," and "Higher Cost."

The "SP/PUC" subalternatives would not operate in any noticeably different ways than the Base Case. It does provide for slightly less traffic conflicts withmore grade separations and one or two stations would become elevated, but these would not substantially alter either the average speed, vehicle-miles traveled or annual operating costs.

The "Lower Cost" light rail alternative is significantly different in operations from the Base Case, as it would employ smaller, single-unit PCC-type vehicles. As a result, 75 of these smaller 50-foot LRVs would be required to handle the same passenger loads as 45 large, articulated LRVs. Average speeds and passenger demands would both be about 10 to 15 percent lower than in the Base Case. The same $2.05 unit cost was used to arrive at an annual operating cost figure of $5.85 million, about 6 percent higher than the Base Case Light Rail.

The "Lower Cost" Busway alternative would continue to employ large superbuses, while both vehicle-miles and passenger demands would be reduced due to about a 10 to 15 percent drop in the average operating speed. The same $2.20 cost was used to generate an annual operating cost estimate of $6.40 million, about 12 percent lower than the Base Case Busway.

The "Higher Cost" light rail and busway alternatives would achieve about the same average operating speed due to the addition of grade separations wherever delays to transit would occur at intersecting cross streets. As a result of these and other upgrading improvements, a 15 to 20 percent gain in average speed would be achieved, resulting in corresponding increases in both ridership demand and vehicle-miles traveled. Busway VMT would increase by 23 percent, while light rail VMT would increase by 11 percent. Unit costs would decrease slightly (about 5 to 10 percent) for both alternatives due to the increased vehicle utilization (efficiency).

"Higher Cost" light rail is projected to cost $6.0 million per year to operate, an 8.5 percent increase over the Base Case, while the "Higher Cost" Busway is expected to cost $7.8 million per year, a 7.1 percent increase.

SPRR "Purchase of Services"

Table 33 presents the estimated costs of purchasing transit services from the Southern Pacific Peninsula commute operations in the form of free transfer arrangements for arriving County transit riders. A figure was arrived at for planning purposes here which represents an average between the present SP train fares (weekly pass rates for one- and two-zone rides) of about $0.60 and the estimated costs based on the annual operating cost per passenger on the light rail system -- $0.40. The average of these was taken to be $0.50 per rider. The estimated annual ridership transferring to Southern Pacific's Peninsula trains from County transit vehicles was estimated in the patronage forecast work (see Working Paper No. 5).

The estimated annual costs of purchasing SP passenger train service for in-County riders ranges from a low of $2.3 million for the Bus Preferential Treatment alternative (4.6 million transfers) to a high of $3.4 million (6.8 million transfers) for the "Higher Cost" light rail and busway alternatives.

It should be recalled that Southern Pacific trains presently leave San Jose in the morning peak with over 7,500 seats, less than half of which are normally filled upon leaving Santa Clara County. Thus some 3,500 to 4,000 seats appear to be presently going unused on SP trains in Santa Clara County. The opportunity exists to utilize these seats at virtually no additional cost to SP if a favorable fare and transfer arrangement can be worked out and if the County were to implement a major transit feeder service to the SP train depots, particularly the one at San Jose. This could be accomplished by either a light rail or busway extension of the SP through San Jose or connecting express buses on preferential treatment facilities.

Table 33
COST OF PURCHASING SERVICES FROM THE SOUTHERN PACIFIC RAILROAD

Transit Alternative	Rate	Annual Riders	Estimated Cost (Millions of Dollars)*
Bus Preferential Treatment	$0.50	4,600,000	$2.30
Busway Transit	0.50	6,000,000	3.00
Light Rail Transit	0.50	6,400,000	3.20
Busway Sub-Alternatives			
SP/PUC	0.50	6,000,000	3.00
Lower Cost	0.50	5,600,000	2.80
Higher Cost	0.50	6,800,000	3.40
Light Rail Sub-Alternatives			
SP/PUC	0.50	6,400,000	3.20
Lower Cost	0.50	6,000,000	3.00
Higher Cost	0.50	6,800,000	3.40

*All costs are as of June 1976.

It is stressed that these costs indicated above in Table 33 are intended to provide an order-of-magnitude estimate for planning purposes only and are subject to negotiation with SP officials. They constitute a starting point for discussions and could be higher or lower depending upon the transit fare sharing formula eventually agreed to by all parties involved.

FARE REVENUE ESTIMATES

Table 34 presents annual fare revenue estimates for the various transit alternatives based on the patronage forecast estimates contained in Working Paper No. 5. The study assumptions regarding fare policies were set by the Transit District Governing Board at the outset of this study and are understood to be as follows:

- Local bus service fares to continue at 25¢, with the present system of discounts for seniors, youth and the handicapped.
- New transitway systems should have fares set at that level necessary to recover 30 percent of operating costs.
- Credit should be given for the transit fare already paid in going from one transit system or vehicle to another.
- Free transfer arrangements should be assumed for arriving County transit riders desiring to transfer to SP trains for in-County service.
- SP fare rates should be assumed to be the same as the County's transitways for in-County trips.

As a result of these fare policies and using the current fare recovery rate of 17¢ per passenger carried assuming a 25¢ base fare, the annual fare revenues were estimated and shown in Table 34. Based on preliminary analysis, it appears that a 25¢ base fare would also be sufficient

Table 34
FARE REVENUE ESTIMATES FOR TRANSIT "BASE CASE" ALTERNATIVES

Transit Alternative	Base Fare Assumed	Local Bus Fare Revenues[1]	Transitway Fare Revenues[1,2]	Total Revenues
Baseline Bus	$0.25	$5.83	N/A	$5.83
Improved Local Bus	0.25	8.26	N/A	8.26
Bus Preferential Treatment	0.25	5.15	$1.65	6.80
Busway Transit	0.25	4.86	2.43	7.29
Light Rail Transit	0.25	4.86	2.92	7.78

[1]Assumes an average fare recovery of $0.17 per passenger, in line with current District operating experience.

[2]Assumes approximately 15 percent of all transitway riders would arrive via local bus and that therefore the local bus system receives credit for the transit fare under a free transfer policy here.

to recover 30 percent of the light rail transit system's operating costs. It would not be sufficient to recover 30 percent of the busway's operating costs, however, and the base fare charged would have to be raised to something like 35¢. These recovery rates are very dependent on the forecast 1990 patronage levels being achieved and include in the operating costs to be recovered the cost of purchasing free transfer transit services from Southern Pacific, since that assumption was made when making the patronage forecasts.

Table 35 shows the farebox recovery percentage for the different transit alternatives. Note that the 516-bus system is estimated to recover about 15 percent of its annual operating costs from the farebox, while each succeeding alternative would slightly lower that percentage to the 12 to 13 percent range because of the switchover of some local bus riders to the more attractive express bus and transitway alternatives.

Table 35 shows that assuming a 25¢ base fare, the light rail system would be expected to recover about 33 percent of its operating costs plus the cost of purchasing SP's services. The busway system would recover less than 25 percent of its and the SP's costs under the same fare assumption.

Finally, Table 36 presents the annual fare revenue estimates for the light rail and busway subalternatives, which information is needed for the alternatives analysis and cost comparisons. A base fare of 25¢ was assumed throughout, and patronage farecasts for the "lower" and "higher cost" subalternatives were based on the patronage forecast sensitivity analyses performed as part of the modal split forecasting work and reported on in Working Paper No. 5. Fare revenue estimates for the light rail subalternatives range from a low of \$2.4 million to a high of \$3.4 million, while those for the busway range from \$2.1 to \$3.4 million.

Table 35
PERCENT OF OPERATING COSTS RECOVERED FROM FAREBOX REVENUES

Transit Alternative	Annual Operating Costs*	Annual Farebox Receipts	Percent Farebox/ Operating Costs
Baseline Bus	$38.60	$5.83	15.1
Increased Local Bus	72.60	8.26	11.3
Bus Preferential Treatment			
Local Bus	38.60	5.15	13.3
Preferential Bus	11.60	1.65	14.2
Busway Transit			
Local Bus	38.60	4.86	12.6
Busway	10.30	2.43	23.6
Light Rail Transit			
Local Bus	38.60	4.86	12.6
Light Rail	8.73	2.92	33.0

*Operating costs for transitway/express bus portions include SPRR "purchase of services" costs.

Table 36
FARE REVENUE ESTIMATES FOR LIGHT RAIL AND BUSWAY SUB-ALTERNATIVES

Sub-Alternative	Base Fare Assumed	Local Bus Fare Revenues	Transitway Fare Revenues*	Total Revenues
Light Rail Transit				
Base Case	$0.25	$4.86	$2.92	$7.78
SP/PUC	0.25	4.86	2.92	7.78
Lower Cost	0.25	4.86	2.43	7.29
Higher Cost	0.25	4.86	3.40	8.26
Busway Transit				
Base Case	0.25	4.86	2.43	7.29
SP/PUC	0.25	4.86	2.43	7.29
Lower Cost	0.25	4.86	2.06	6.92
Higher Cost	0.25	4.86	3.40	8.26

*Assuming a 25¢ base fare.

CHAPTER VII

ENVIRONMENTAL ASSESSMENT

The material in this chapter was derived from Working Paper No. 4: Land Use, Socio-Economic and Environmental Considerations. That paper reported on the potential impact that transit alternatives will have on the natural, human and built environment and ways in which impacts can be shaped to the benefit of the community at large.

The impacts of the various alternatives on transportation facilities and automobile traffic was discussed earlier in Chapter V. Land Use analysis included general plan compatibility, joint station/building opportunities, collateral development possibilities and station area land use impact. Socio-economic evaluations involved such areas as community services, relocation, economic pressure around stations, neighborhood character and equity considerations. Natural environment considerations were air quality, energy, noise, visual, ecosystems, water resources, soils and geology, parks and open space and historic and archeological sites.

Analysis identified important opportunities for land use, socio-economic and environmental benefit from alternative transit modes and corridors in Santa Clara County. Reduced vehicle congestion and travel time, improved air quality, energy conservation, increased accessibility/mobility, avoidance of land taking and displacement, control of urban sprawl and reinforcement of general plan objectives are all possible to greater or lesser degree with alternative modes and corridors. Transit facilities will provide numerous site-specific opportunities where county, cities, other public agencies and private developers can cooperate to extend transit benefits through joint and collateral development.

Analysis indicated no insurmountable land use, socio-economic or natural environmental constraint which would automatically preclude any particular mode -- trend bus, bus preferential treatment, busway, light rail at grade or light rail elevated. Likewise, no insurmountable problems were identified

to preclude a particular corridor. There are sensitive locations in each corridor where mode difference could affect acceptability. And, each corridor presents a different set of circumstances to challenge transit system designers and avoid undesirable side effects.

LAND USE

Compatibility with General Plans

This subject area is covered in Chapter IX which deals with Goals Achievement.

Collateral Development/Redevelopment

Collateral development has been defined as high density residential, commercial or industrial uses that are clustered within one-quarter mile or a five minute walking distance from stations on the proposed transit corridors. The density and design of development must be related to the increased convenience made possible by the transit facility. This convenience normally means that the need for a work trip automobile is eliminated for those individuals who can both live and work within this distance of a transit stop.

Collateral development possibilities tend to be correlated with the extent of long term commitment to transit facilities and with the number of stations serving the system -- fewer stations focusing the market and opportunities into a limited number of areas. Those transit alternatives requiring a substantial investment and more permanent facilities with higher conversion costs -- the transitway and stations associated with the busway and light rail alternatives -- appear to provide the greatest incentive for collateral development.

The initial analysis of collateral development potential on a corridor level is based on the assumption that new development will occur on existing vacant agricultural land. The existing development in Santa Clara County, for the most part, is relatively new. There are large areas of undeveloped land still available, and therefore, in the opinion of officials, the increased

development costs required to redevelop and intensify existing urban land uses would most likely not be justified.

Maximum potential at five station areas is indicated for the Blossom Hill and Monterey corridors. The De Anza and SP Lick Branch/Mainline corridors have three station areas with high collateral development potential. Two stations on the Guadalupe corridor are high in collateral development potential, while the Vasona corridor appears to have minimum opportunity of this type.

<u>Joint Station/Building Opportunities</u>

Joint building station development is defined as the integration of residential, commercial or employment facilities with the design of a station. The term suggests a smaller scale of facilities than is implied by collateral development. Examples of joint station/building development include a small shopping center which has a station as its main focus and the use of air rights above a station for the intensification of commercial or employment uses. Joint building/station development emphasizes the public nature and multi-use character of a combined commercial and transit facility and provides a focus for the neighborhood, clustering activities that can mutually reinforce each other. The combination of a neighborhood center and a transit station can provide identity to a neighborhood and serve as the beginning of an environment that encourages less dependency on the automobile.

Experience indicates that joint station/building opportunities are also greatest among transit systems associated with large scale, fixed facilities which imply permanence, a long term investment commitment and expensive conversion costs if the right-of-way were to be modified for other uses such as autos. The implication, then, is that the alternatives associated with the transitway -- light rail and busway -- will greatly enhance joint station/building opportunities as opposed to the remaining two alternatives where substantial investment in permanent facilities is unlikely and not

required, and that the opportunities are greater for light rail than for busway. Given this general indication, it is necessary to view these opportunities in light of the specific corridors.

The most reasonable application of joint development, aside from small single-use facilities such as a convenience market, is adjacent to the large regional commercial centers like Almaden Plaza on the Blossom Hill corridor. In this case there is an advantage in clustering facilities, and where the area is traversed by the transit system it can simply be bridged over to integrate new development with the existing complex.

A preliminary analysis of stations for potential air rights development indicated that opportunities are not extensive. It is only reasonable to use air rights where other land is not available, and the location is conducive to high density development. Most potential station locations identified were either single family residential areas where high density development would not be appropriate or in low density industrial areas which require land for storage or parking uses. Within the context of limited opportunity in all corridors, Blossom Hill, SP Lick/Mainline and the Monterey corridors were found to yield somewhat greater opportunity for joint station/building development than did the other corridors.

Station Area Land Use Impact

It is important to assess the impact each of the alternatives has on the land use of the area adjacent to the station. The possible range of impacts is large and depends on a number of factors exogenous to the alternatives such as local government policy, development trends and market forces, availability and cost of land, and the physical and locational characteristics of the surrounding area.

Experience suggests that the station area impacts of the alternatives are limited to the higher speed transitway systems. The baseline and preferential bus alternatives lack focus due to the large number of stops,

changeability of routes and little or no stationary physical commitments that would create impacts. Therefore, the potential impacts were primarily assessed for the transitway alternatives.

Analysis revealed little potential for major impacts in the station areas unless certain actions are undertaken. This is due primarily to two factors. One, stations as currently located would primarily serve existing demands. Two, while vacant land is presently available in many station areas, current development plans do not promote desired high density growth in these areas for maximum transit support.

Given the limited nature of the probable impact in any corridor under present circumstances, the De Anza, Blossom Hill and SP Lick/Mainline corridors have more potential for station area impacts than do the other corridors.

It should be noted that historically most major land use impacts resulting from transit system implementation have been associated with rail facilities since very few busways have been built and these only recently. It should also be stressed that the degree to which land use is impacted by rail facilities is to a considerable degree dependent upon the will and desire of the community. Rail facilities can provide an opportunity for shaping and structuring urban growth in dramatic ways, but other circumstances must be favorable and appropriate actions and incentives -- such as revised zoning regulations -- provided. Properly coordinated land use development can produce a variety of benefits, including additional transit system utilization and less dependence on the automobile. These potential benefits warrant serious consideration in evaluating the alternative transit modes and corridors being considered in this study.

SOCIO-ECONOMIC

Community Services Impact

Adverse community service impacts might be caused by transitway location severing or disrupting existing utilities, schools, public buildings or other facilities. Existing bus and preferential bus alternatives, with their associated minimal construction requirements, will have negligible impacts on community services. An at-grade transitway should have less construction impact but could have greater long-term disruptive effect than aerial transitway if cross-circulation is impaired.

It must also be realized that transit facilities can have a positive impact on community services by making them more accessible to a larger number of people, particularly the elderly, the handicapped and other transit-dependent groups. The degree to which the various alternatives improve mobility and accessibility was discussed in Chapter V of this report.

Although it is unlikely that any community service facility will be displaced by construction, pedestrian access to and from certain facilities may be permanently restricted due to transit-related structures (i.e., fencing, noise barriers, and approximately five to ten road closures). This is most significant in the Blossom Hill corridor since it has a higher number of community facilities within a quarter mile of the line than in other corridors. Also, at-grade transitway signalization may cause traffic delays of ten to twenty seconds, which could delay emergency services, including fire protection, police and ambulance services. Conversely, positive impacts on highway travel speeds resulting from the diversion of some drivers from automobiles to transit (as discussed in Chapter V) could facilitate the movement of emergency vehicles in other areas.

Construction of a transitway could result in interruption or severance of Southern Pacific spur tracks from the main railroad line along several of the corridors unless proper design provisions are made. These spur tracks are important to a number of active shipping industries located along the tracks. Severe disruption of freight service could require an industry to relocate or seek other, perhaps more expensive, means of linking up with the main railroad line or transporting the goods. Future uncertainty with regard to available energy supplies underscores the need to consider and maintain railroad service as a relatively cheap and efficient means of long-haul transportation. Approximately 30 industries could be affected, primarily along the Vasona and Monterey Highway/SPRR corridors, and special design efforts would be necessary at those locations.

Some major utility lines may be affected by short-term construction and require relocation. The most notable example is the water distribution mains along the De Anza corridor (Alternate #1A) located in the railroad and transit right-of-way. Future access to utilities such as water and sewer mains, located underneath the transitway could pose major problems and costs, particularly if maintenance requires excavation beneath the transit structure. An aerial transitway could pose special problems where support columns must be placed across underground utilities or overhead. Relocation and/or special design provisions will be required under such circumstances and these costs are included in the estimated cost of each alternative.

Long term indirect impacts on community facilities may result from noise or visual intrusion by transit-induced traffic or secondary impact on infrastructure due to transit-induced land development. The intensification of land use within a selected corridor could basically be expected to have two types of impact on urban infrastructure: (1) a reduction in overall community utility, street and public facility construction and maintenance costs where such costs are proportional to the amount of land covered by development, e.g., miles of streets and utility mains, number of police and fire stations; and (2) possible increases in site development and maintenance costs where such costs are proportional to density of land use, e.g., more police surveillance per acre, more students per acre.

Relocation

An important criterion by which to judge any alternative is the degree of displacement and relocation of various land uses required. Minimizing displacement and relocation of various land uses is desirable to maintain existing neighborhood viability and stability. Relocation of residents and businesses would probably not be required for implementation of a trend bus or preferential bus treatment system because construction would be minimal. Relocation requirements for transitway alternatives however, could be appreciable if they are not properly located due to major construction requirements such as clearance of right-of-way and permanent stations/parking lots, and disruption of SP spur tracks. Relocation requirements can generally be expected to be greater for a busway than for a rail facility based on right-of-way width assumptions. Although there is a nominal difference in the width of aerial and at-grade guideways, aerial affords greater joint use potential (e.g., street parking or industrial use under the guideway) which could reduce required property acquisition and displacement.

In addition to analysis by transit mode, the corridors were analyzed to determine differential relocation requirements. The results are shown in Table 37. It is important to note that the table reveals little displacement in any corridor since existing right-of-way and state-owned property will be extensively used. The highest impact to residential structures will be along the Blossom Hill Corridor; business displacement will be negligible. The most significant potential displacement impact would be to 30 shipping industries which could require relocation due to disruption or blockage of SP spur tracks, primarily along the Vasona and Monterey Highway/SPRR Corridors, if special provisions are not made. Development of the SP Mainline/Lick Corridor would also cause some business displacement and possibly affect SP users.

Table 37
RELOCATION OF HOUSING AND BUSINESS UNITS ASSOCIATED WITH TRANSITWAY*

Corridor	# Residential Units Displaced	# Businesses Displaced	S.P. Users Potentially Affected**	# Feet Along Corridor In Question***	Other****
DeAnza #1A			1	7,600'	
DeAnza #1B	7[1]				
DeAnza #1 A & B			1		
Vasona #2			13	8,000'	
Blossom Hill #3	35[2]			3,000'	
S.P. Main Line/Lick #4		3	2	6,500'	
Monterey Highway/S.P.R.R. Alt. #4			16	2,400'	1,600'
Guadalupe #5				1,000'	

*Approximate number determined from aerial photos.
**Railroad spur may be cut off by transitway, resulting in relocation of the shipper; precise number affected will be determined in preliminary engineering phase.
***Transitway within 100 feet of structures; could result in access problems and/or the taking of yards (residential units) or parking lots (business structures).
****IBM parking lot.
1. On state owned property.
2. 10 structures are on state owned property.

SOURCE: Aerial photos (December 1975), Scale: 1" = 200'.

Economic Pressure Around Stations

Economic pressure around stations will vary with transit mode in the same general manner as land use impact. Greater investment in transitway facilities and the less potential reuse of guideway (i.e., rail transitway, especially aerial) should produce greater land value and rent levels adjacent to transit stations. Increased mode speed and resulting patronage (i.e., aerial guideway) also increases economic pressure around stations.

Similarly, systems with fewer stops and with focused station areas would have a higher potential for creating economic pressure. Therefore, the baseline bus and preferential bus alternatives would have negligible impact whereas the transitway alternatives could precipitate land value increases. In particular, a rail system would yield a higher impact than a busway system and an aerial rail system would produce more pressure than would an at-grade rail system.

For the same reasons that the land use impact will be limited, the economic pressure around stations will probably not be extensive under present circumstances. However, the economic pressure will be somewhat greater around the stations in the De Anza and Blossom Hill Corridors than in the others.

Neighborhood Character

Neighborhood disruption occurs when some change in the physical or social surroundings affects an individual's perceived or real association with other individuals, groups or places within his own neighborhood. Compatibility with neighborhood character appears to be inversely related to the physical mass, visibility, noise and traffic congestion associated with a mode. Buses can most easily mix with existing auto and truck traffic without intrusion, while fixed guideways, especially an aerial structure in proximity to sensitive uses (homes, parks, etc.) are likely to be viewed as incompatible with existing character.

Because of the potentially greater impact of the fixed transitway and stations on the cohesiveness of established areas, analysis focused on the likely magnitude of such impact on a corridor level. Specifically, the following conditions were examined:

- Physical intrusion of the right-of-way through an established homogenous area.

- Incompatibility of a proposed station and/or parking lot with the character of the surrounding area.

- Extreme closeness of the right-of-way to a well-established residential area.

Table 38 summarizes potential intrusion on neighborhood quality due to the transitway and stations. The table indicates that in localized areas the closeness of the right-of-way to residences may cause loss of privacy (visual and noise). Increased traffic flowing to the stations and parking lots may disrupt the tranquility and integrity of some well-established residential neighborhoods. Also, some physical barriers may be created by associated transit development -- particularly with respect to pedestrian circulation. It appears that the greatest impact on neighborhood character would be in the De Anza, Vasona, Blossom Hill and SP Lick/Mainline corridors.

It is important to note that adverse impacts may be offset by potential enhancement of neighborhood character. For instance, development encouraged by the transit system could improve neighborhood quality and reinforce desired social and physical objectives. Also, increased accessibility due to the transitway system may increase real estate values -- particularly in proximity to the station -- thus strengthening the vitality of the area.

Finally, joint development and station area development opportunities encouraged by the transit system could provide desired neighborhood facilities and community focus.

Table 38
TRANSITWAY IMPACT ON NEIGHBORHOOD CHARACTER

CORRIDOR	#Feet of transitway extending through a neighbor-hood*	#Feet transitway is within 100 feet of residences (visual and noise intrusion)	# Stations in predominately residential area	# Station parking lots in predominately residential area
DeAnza #1A	-	7,600'	1	1
DeAnza #1B	-	-	3	3
DeAnza 1A & B	-	-	2	2
Vasona #2	-	8,000*	2	2
Blossom Hill #3	3,000'	3,000'	4	4
S.P. Main Line/Lick #4	-	6,500'	3	3
Monterey Hwy/S.P.R.R. Alt. #4	-	1,200'	1	1
Guadalupe #5	-	1,000'	2	2

* 6,000 for light rail and 8,000 for bus guideway

Source: Existing Land Use Maps Prepared by Santa Clara County Transportation Agency; Aerial Photos (December 1975), Scale: 1" = 200'

Equity Considerations

Equity considerations, the question of who will benefit versus who will pay for the transit system, are most apparent in economic terms. Several potential impacts are suggested here which merit further consideration after a financial plan is developed. Equity to local government as measured by the distribution of land removed from the tax roles does not vary greatly with transit mode. Maintenance and storage yards require the largest land taking; there is little difference among modes in their storage yard requirements. The relatively small tax impact of transitway and station site land takings may be offset by increases in tax revenue on economic activity around the stations. Distribution of user and nonuser benefits will not vary significantly among alternatives. In all cases where public financial support is given, users will benefit more than nonusers. However, the differential is mitigated by increased highway travel speed, increased employment and land values.

Equity to local governments can vary between corridors. Communities in proximity to the transit guideway will receive greater benefits relative to surrounding communities. On this basis, equity between governments would be maximized by development of the De Anza and Vasona Corridors.

NATURAL ENVIRONMENT

Air Quality and Energy

Bay Area concentrations of carbon monoxide (CO), nitrogen oxides (NO_x) and reactive hydrocarbons (RHC) presently exceed state and Federal ambient air quality standards. Each of these pollutants is primarily attributable to auto emissions. As such, an important critieron of alternative analysis is the degree to which auto VMT is reduced, thereby reducing air pollution. VMT is also a primary indicator of energy use.

Based on VMT, one could expect an approximate one percent improvement in County air quality or a one-quarter percent improvement in Bay Area air quality attributable to a five-corridor transitway system. Energy savings would be of a similar magnitude. Although VMT reductions of this magnitude appear numerically small, they are comparable with other transportation management strategies (e.g., carpooling, staggered work hours). Transit improvements present an opportunity to achieve greater vehicle travel reduction in the event of gasoline shortages or higher prices. As an alternative to the automobile, transit represents a means of maintaining mobility while reducing pollution or energy consumption.

Analysis of 1990 travel data indicates that elevated light rail would maximize reduction of auto VMT and hence air pollution and energy usage. The rank ordering of the other alternatives on the basis of VMT (from maximum to minimum reduction) is at-grade light rail, busway, expanded local bus, preferential bus (TSM) and baseline bus alternatives.

On a corridor level, air pollution and energy consumption will be maximized in the SP Mainline/Lick Corridor, followed by the Monterey, Vasona, Guadalupe, Blossom Hill and De Anza Corridors, in that order.

Noise and Vibration Impacts

The major noise and vibration aspects to be considered in association with transit alternatives are related to vehicle operation. Station traffic and construction noise, while requiring careful attention, are relatively minor considerations in comparison. It should be stated at the outset that study results to date indicate that all noise and vibration impacts likley to be produced by the transit alternatives under consideration can be mitigated to meet existing and currently proposed EPA, County and city noise standards.

Light rail or busway service of the type proposed would generate a peak passby noise level of 78 dBA and a day-night weighted noise level (L_{dn}) of 50-60 decibels 50 feet from the source. This assumes 45 MPH speed,

state-of-the-art vehicles,* headways approximating five minutes in peak periods and ten minutes off-peak between the hours of 6 AM and 10 PM, guideway at-grade with no noise barriers. Sound of the $L_{dn} = 60$ intensity falls within the bank of acceptability prescribed by the proposed Santa Clara County "critical" noise standard ($L_{dn} \leq 65$dB) and San Jose "short range" standard ($L_{dn} \leq 60$dB) in residential areas. However, transitway noise would cause the EPA standard for residential areas ($L_{dn} \leq 55$dB) to be exceeded within approximately 100 feet of the transitway alignment.**

Where the transitway alignment passes along an arterial street or frequently used rail line, transitway noise would be masked by existing traffic. It must be noted, however, that restrictions could conceivably be imposed on the manufacture of new motor vehicles, especially trucks, which could reduce traffic noise by perhaps 10 dB during the next ten years, thus lowering arterial street noise (e.g., 20,000 vehicles per day at 45 MPH) to a level comparable with the proposed transitway. Freeway and railroad traffic will almost certainly continue to be noisier than any transit guideway.

Compared to other transit options, the at-grade transitway is midrange in terms of noise impact. Elevated guideway would increase wayside noise levels by about 5dB compared to at-grade operation. On the other hand, existing small buses are about 3dB quieter than the bus assumed along the guideway and will have least impact if routed over existing arterial streets.

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* Boeing LRV on continuous welded rail and 1976 GMC 49-passenger diesel bus assumed for comparison.

** The proposed County "cautionary," San Jose "long range" and Los Gatos standards are also $L_{dn} \leq 55$dB for exterior noise in residential areas.

To meet new rail vehicle standards imposed by UMTA, manufacturers have employed quieter traction motors, heating and ventilating equipment and resilient wheels capable of reducing vehicle noise by five to ten decibels compared with older operating equipment. Use of continuous welded rail with resilient rail fasteners as assumed for light rail application in Santa Clara County is capable of lowering noise levels five to ten decibels over conventional track systems. The continuous weld eliminates the distracting "clickety-clack" sound of conventional track. Wheel/rail noise is largely dependent upon the condition of the rail; deterioration can mean noise increases of ten to fifteen decibels.

A regular maintenance program of rail grinding and wheel truing can prevent such deterioration from occurring. The best control of wheel squeal is good design; i.e., the minimum radius of curves should exceed 100 times the length of wheelbase.

Construction noise impact will vary with design and construction techniques chosen. At-grade construction involves a shorter construction period than aerial and subway construction and less potential use of pile drivers, jackhammers and other noisy equipment. Baseline bus and preferential bus present little potential construction noise impacts, unless exclusive lanes or ramps were constructed to expedite bus movement.

Ground condition underlying much of the study area is conducive to transmission of perceptible ground vibration out several hundred feet from any rail facility. Continuous welded rail, resilient fasteners and rail grinding should mitigate ground vibration along at-grade guideway segments. Light rail operation would present greater vibration potential if aerial sections were to be utilized and the structures were to be implanted in shallow bedrock overlain with clay. In such areas, special design treatment (e.g., floating slab foundations) might be needed to avoid vibration impacts. Bus options present no particular vibration problem.

Noise level impacts would vary between corridors. The Guadalupe, Southern Pacific/Lick Branch and Monterey Corridors appear to have the fewest noise sensitive areas. In the West Valley Freeway, wayside noises could be avoided by placement of the transitway in the center of the right-of-way. However, this would preclude more efficient land use possible by building the transitway to the side. Noise barriers could be effectively used to mitigate the noise while allowing optimum land use. Noise barriers could also be effectively used in the residential areas along the Blossom Hill and De Anza Alternate A alignments since there are relatively few at-grade crossings and residences are low profile.

The Vasona Corridor, like the Monterey Corridor, is relatively constrained from an alignment standpoint and has a large number of at-grade crossings which will dilute the value of noise barriers. The Vasona Corridor has roughly three times as many residential dwelling units within 100 feet of the right-of-way. Immediately adjacent to the alignment and south of I-280, it may not be possible to effectively shield second story apartments from wayside noise.

Noise impacts associated with station access traffic are likely to be minimal. Where noise levels have potential for impact -- in residential areas -- they might be successively avoided by careful design of traffic circulation.

Visual Impacts

Visual impact is likely to be proportional to the mass of the guideway and stations. Therefore, an elevated guideway will be the greatest visual intrusion to the environs. At-grade guideway transit with platform stops have significantly lower visibility except in sections where aerial structures (e.g., grade separations) are proposed.

There is a differential visual effect between at-grade rail and busway alternatives. Light rail guideway has overhead wires which could be perceived as a visual intrusion whereas busways require a much wider guideway.

The tradeoff between these visual effects depends on the perception of the viewer. Baseline bus and preferential bus alternatives with no related fixed facilities would have the lowest visual impact.

Those corridors with the greatest surrounding residential land use will be subject to greater visual intrusion. These corridors include the De Anza Alternate A, Blossom Hill, the SP Mainline/Lick and the Monterey Highway Corridor.

Ecosystems

Ecosystem impact as measured by proximity to aquatic habitat (stream crossings) and proximity to heritage trees indicates small differences among guideway alternatives. Busway impact may be greater than light rail insofar as right-of-way requirements are estimated to be greater. Aerial guideway is likely to have greatest secondary impacts due to higher speed and seating capacity which could place urban growth pressure on agricultural land or unstable hillside areas. Baseline bus and preferential treatment alternatives are assumed not to require special right-of-way development having ecosystem impact.

Transitway development carries the potential to alter, positively and/or negatively, the vegetation, wildlife habitat and aquatic systems along each of the study corridors and in the West Valley area in general. The numerous stream crossings and the location of parking lots on streams could result in the removal of riparian vegetation, create a temporary siltation problem during construction and add a polluted stormwater runoff following construction. Riparian vegetation, the habitat most significant to wildlife, would potentially be removed at all stream crossings. These impacts could occur on all corridors except the Monterey and Vasona and measures must be taken to avoid or to mitigate these impacts if possible. The De Anza Corridor alignment which crosses eight to ten streams could have a high impact upon riparian vegetation. The De Anza, Vasona, Blossom Hill and SP Mainline/Lick Corridors would have parking lots with potential direct drainage to streams.

Construction of the proposed transportation system along existing railroad and highway rights-of-way would result in the removal of grasses and "weeds" which have reduced value to wildlife. Noise and air pollution associated with railroads and highways reduce the significance of adjacent vegetation to all but the most tolerant species. This right-of-way vegetation type represents the major vegetation removal in the Vasona, SP Mainline/Lick, Monterey and Guadalupe Corridors. Corridors that follow the undeveloped West Valley Freeway right-of-way (De Anza and Blossom Hill) have the greatest impact on urban grasslands and orchards, vegetation types significant to a greater number of species.

Although differential impacts between alternatives in specific ecosystem components exist, when viewing ecosystem impact as a whole, there is little difference between alternatives. However, development of the SP Mainline/Lick and Guadalupe Corridors would have less negative impact than it would in other corridors.

Water Resources

There is insignificant variation between the potential impacts of the at-grade busway and light rail alternatives as alignments, station and parking lots are identical or very similar. Baseline bus and bus preferential treatment were assumed to have no particular water resource impacts. Aerial guideway impacts should be similar to at-grade transitway impacts in most respects, e.g., stream crossings, potential construction, siltation, parking lot drainage, and proximity to percolation ponds.

Estimates of surface flooding and potential impacts on surface water quality were completed using the projection of the 100-year flood plain boundaries, as supplied by the Santa Clara Valley Water District, onto plan and profile maps of the proposed transportation plan. Analysis indicated that shallow surface flooding and deeper water associated with the 100-year flood plain of area streams could affect portions of all transportation corridors. Many of the stations and parking lots are within the boundaries of the 100-year floodplain. Floods in these areas could potentially disrupt service and perhaps damage automobiles in the parking lots.

Proximity to streams is indicative of potential degradation of water quality. All corridors except Vasona and Monterey cross streams. However, the use of siltation controls during the crossing of streams can reduce the magnitude of siltation and maintain the present water quality conditions. Parking lots would be located near streams in all corridors except Monterey and Guadalupe. These parking lots would have minor potential to alter the quality of receiving waters through the addition of a stormwater runoff with slight concentrations of oils, tars, greases and other petroleum-related compounds.

The Monterey Corridor could require partial filling of one or two percolation ponds, depending on the precise alignment selected. Such encroachment counters efforts to raise the subsurface water table in the County.

Construction retention reservoirs in areas of prime percolation soils to retain the stormwater runoff from parking lots and allow a slow percolation to the groundwater table has the potential to create a positive impact to groundwater supplies. Prime percolation soils are not extensive in the area, but are characteristic to portions of all corridors. In light of the potential impacts discussed, it appears that the transitway In the De Anza and Vasona Corridors would have less negative impact than it would in the other corridors.

Geology and Soils

Soils and geologic impact are closely associated with ecosystem impacts. Erosion and siltation could accompany all guideway construction, but appears potentially greatest for aerial guideway due to secondary urban growth impacts on agricultural land and hillside stability. Requirements for construction materials (concrete, sand and gravel, water and steel) appear greatest with aerial guideway construction. Preferential bus and baseline bus alternatives with no construction would have negligible impact on geology and soils.

Specific soil and geologic constraints vary with specific corridors; in places they present serious impediment to transitway construction. All corridors have extensive areas that have a moderate potential for liquefaction, lurching and lateral spreading during seismic activity. These characteristics

do not present problems except at stream crossings. The bridging of streams in these areas may require engineering consideration to prevent problems arising from lateral spreading. The De Anza and Blossom Hill Corridors parallel a potentially active fault, the Shannon Fault, which is crossed near the Vasona Station on the De Anza Corridor. There is a high potential for ground displacement several hundred feet to either side of the fault, which creates the problem of potential offset when crossing the fault. Engineering design procedures can be used to mitigate the problem.

Impacts to geologic resources were evaluated from a mapping of the U.S. Geologic Survey. Much of the study corridors are underlain by sand and gravel deposit; however, good quality stream gravels occur only at the crossing of Los Gatos Creek on the Blossom Hill Corridor. Commercial extraction may be feasible in this area. Limestone and serpentine deposits occur on the SP Mainline/Lick and Guadalupe Corridors in the hill just south of Oak Hill Memorial Park. The proposed transportation plan should not impact these resources. Impacts from eroding soils, shrink-swell soils and productive agricultural soils were assessed from the USDA Soil Conservation Service mapping of Santa Clara County. Class I and II agricultural soils currently in production were considered in the analysis. The potential for soil erosion is generally low throughout the area. However, portions of the Guadalupe and SP Mainline/Lick Corridors have small areas with soils that have a high erosion potential. Swelling clay which can damage foundations, roads and other structures have a patchy distribution throughout the area, but tend to have a somewhat greater occurrence in the Monterey and SP Mainline/Lick Corridors. Prime agricultural soils currently in an agricultural usage are affected on the Blossom Hill, SP Mainline/Lick, Monterey and Guadalupe Corridors. Orchards are affected on all corridors except the Vasona and SP Mainline/Lick. Nursery vegetation is affected on the De Anza and Guadalupe Corridors.

Parks and Open Space

Parks and open space impacts as measured by guideway proximity to existing parks and opportunity for linear parkway development in conjunction with transit development would be relatively similar for all guideway modes. Aerial

guideway appears to provide greater opportunity for placement of bike and pedestrian pathways and landscaping in a confined right-of-way. Baseline bus and preferential bus avoids guideway proximity to park land but affords no opportunity for linear park development.

Analysis of potential impact of the proposed transitways on city parks, golf courses, designated open space, cemeteries, bikeway corridors, and school playgrounds was analyzed for each corridor. There are no direct impacts to existing city parks. However, planned park/open space areas would be impacted in three areas. The Blossom Hill Corridor crosses the proposed open space area of the Guadalupe River and the adjacent percolation ponds, while the Vasona Corridor parallels 800 feet of the proposed open space along Los Gatos Creek. The De Anza and SP Mainline/Lick Corridors would have an indirect impact (visual, noise, aesthetics) on several parks that are in proximity to the guideway.

Three golf courses would be impacted by the proposed transportation plan; Cambrian Golf Course (private) located on the Blossom Hill Corridor would be divided by a 2,500 foot crossing; Oak Ridge Golf Course (private) adjacent to approximately 3,500 feet of the Blossom Hill Corridor would be indirectly impacted; and the Alma Public Golf Course adjacent to approximately 2,100 feet of the SP Mainline/Lick and Guadalupe Corridors, which could take up to one acre of golf course property.

Bikeway routes are intercepted by all five study corridors and paralleled for short distances by the Blossom Hill, SP Mainline/Lick and Monterey Highway corridors. These bikeways would not be negatively impacted by the proposed transportation alternatives. In fact, additional bikeways could be incorporated into those portions of the De Anza and Blossom Hill Corridors and in portions of the Guadalupe Corridor.

The Oak Hill Memorial Cemetery would be indirectly impacted (visual, noise, and aesthetic) along a 2,500 foot connector between the Monterey and Guadalupe corridors.

Public school playgrounds would be either directly or indirectly impacted on all alignments except the SP Mainline/Lick. The only direct impact occurs on the Blossom Hill Corridor where the alignment bisects the playground (1100 feet) between Branham Senior High School and Altheour Elementary. Approximately one acre of school property would be required.

Taking into consideration the various elements of parks and open space impacts, it is indicated that the De Anza and the Blossom Hill Corridors will be subject to less impact than would other corridors.

Cultural Resources Analysis

Factors considered in the cultural resources analysis included National Register, State of California, and County Landmark and Historic sites, and known and potential archaeological and paleontological areas as described and illustrated in the Santa Clara County Heritage Resource Inventory and a Preliminary Heritage and Archaeological and Paleontological Resource Inventory. Baseline bus and preferential bus alternatives would have no impact on cultural resources.

Historic and archaeological impacts as measured by guideway proximity to known sites would be relatively similar for all guideway modes. No known historic sites would be taken by a guideway.

Two local County Historic Resources could be indirectly impacted (visual, noise, aesthetic and possible vibration) from the development of the Monterey Corridor. The Halt House at 2662 Monterey Road would be within 50 to 75 feet of the alignment, and the Oak Hill Memorial Park would be bordered by 2,500 feet of the Monterey-Guadalupe Connector across the road on Curtner Avenue.

All corridors except Vasona traverse areas of known potential archaeological significance from which artifacts of previous cultures have been extracted. Impacts to archaeological resources can be avoided by conducting a ground survey of those areas of potential archaeological significance. If sites are found, provision can be made for extraction of artifacts prior to construction, should it not be possible to modify the alignment to avoid the area.

None of the transportation corridors encounter designated areas of potential paleontological significance. However, paleontological resources (mastedon bones, tusks, and marine remains) have been discovered in the region and may occur in the corridors as well. Since the potential transitway would require little excavation, it is unlikely that paleontological resources, if present, would be affected.

A transitway would potentially impact an area of trees along a 16,000 foot distance of Monterey Highway. The County Conservation Plan, "A Plan for the Conservation of Resources," does not indicate these particular trees as being heritage trees. However, if this grove is an extension of the black walnut grove along Monterey Highway south of the junction with Bayshore Highway, they would have the same historical significance as the heritage trees.

In consideration of the impacts discussed above, it is apparent that a transitway in the Monterey Corridor would have the most negative impact on cultural resources, whereas it would have the least in the Vasona Corridor.

SUMMARY

Environmental analysis is a complex, multi-faceted component of cost-effectiveness analysis. It is not easily integrated into one overall measure; selection of the most environmentally viable alternatives or corridors depends largely on the decision-maker's perception and weighing of the diverse elements involved. Therefore, it was not attempted to derive a single ranking on the environmental considerations but instead to summarize the findings in graphic form. The comparative evaluation for the mode alternatives are arrayed in Figure 50 and for the corridors in Figure 51. The kinds and locations of environmental opportunities and constraints that can be found in each corridor are shown in Figures 52 through 57.

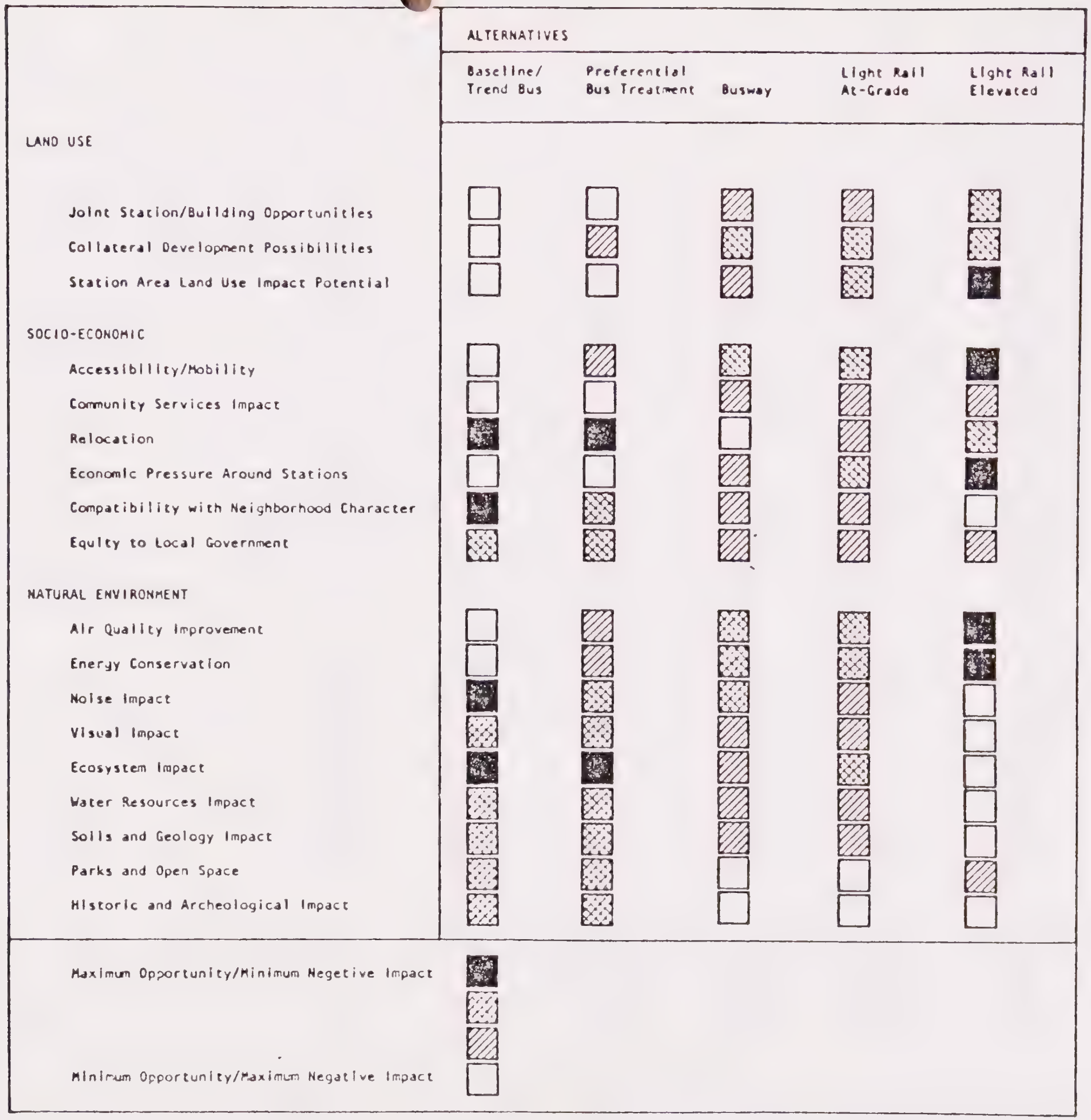

Figure 50
COMPARISON OF ENVIRONMENTAL CONSIDERATION BY ALTERNATIVE TRANSIT MODES

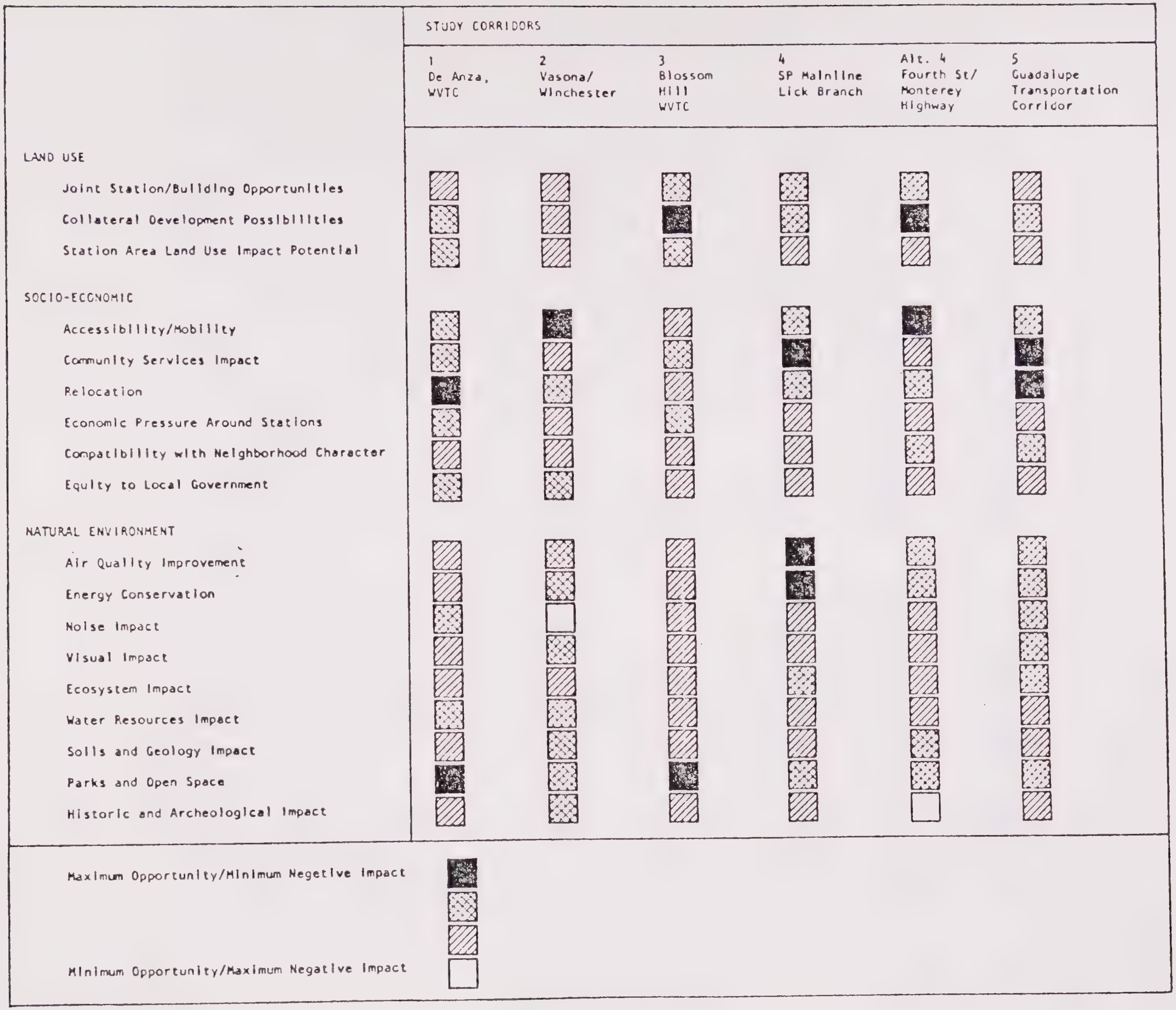

Figure 51
COMPARISON OF ENVIRONMENTAL CONSIDERATIONS BY CORRIDOR

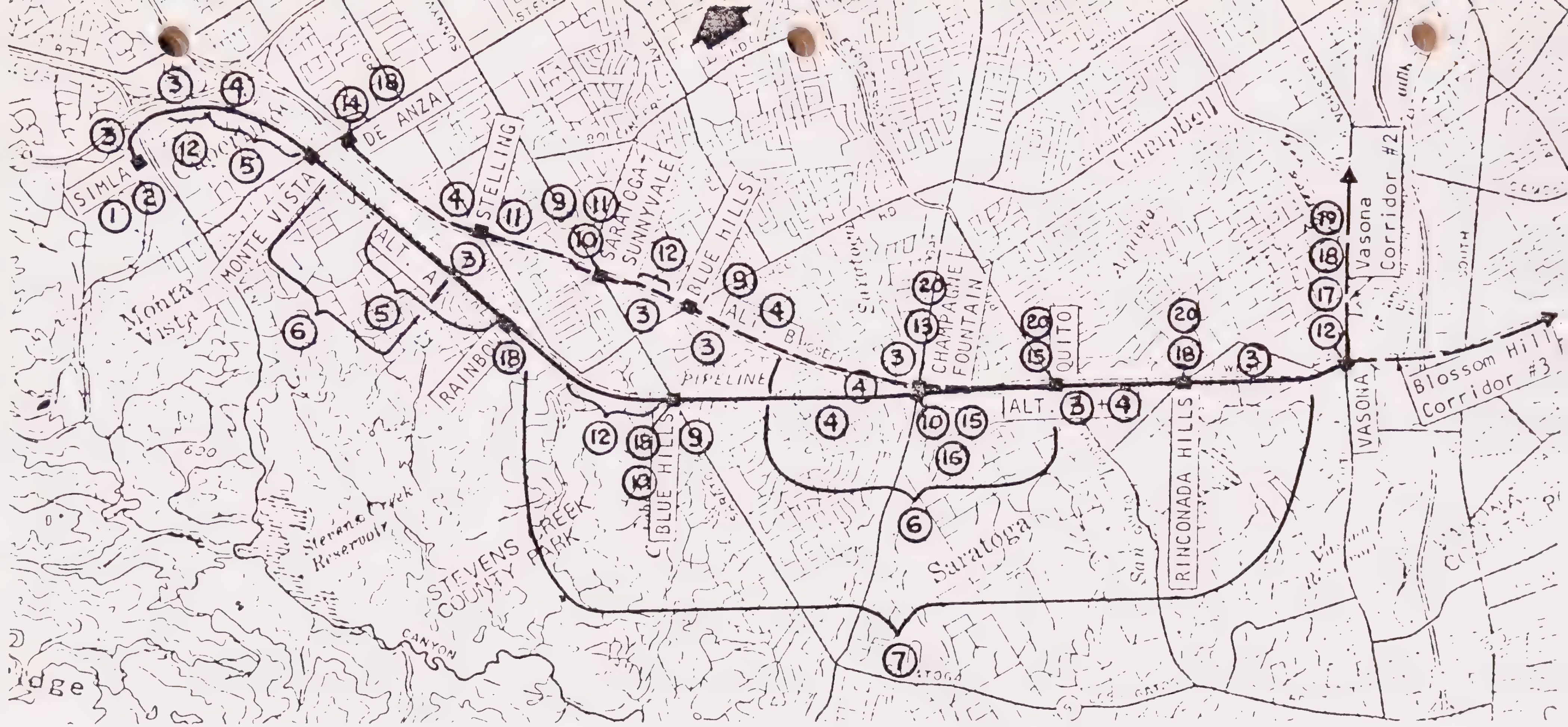

Figure 52
DE ANZA CORRIDOR; OPPORTUNITIES AND CONSTRAINTS

1. Major development potential around station given existing character of area and supportive local development plans.

2. Significant opportunities for collateral development at station area given available or vacant land.

3. Creek crossing requires precaution in design and construction to avoid siltation and degradation of water quality and aquatic ecosystem.

4. Transitway noise and visual impact on adjacent park.

5. Transitway noise and visual impact on adjacent residences.

6. Transitway located in potential archeologic area as indicated by "A Plan for Conservation of Resources," an element of the Santa Clara County General Plan.

7. Structural impacts on transitway running parallel to Shannon Fault -- a potentially active fault.

8. Provides access to Jollyman Park; transitway noise and visual impact on park setting.

9. Bikeway access to Saratoga-Sunnyvale and two alternative Blue Hills stations via Saratoga-Sunnyvale Road and Prospect Road.

10. Moderate development potential around station given existing character of area and supportive local development plans.

11. Potential displacement and relocation of structures due to transitway.

12. At-grade transitway subject to periodic sheet flooding of perhaps a foot in depth.

13. Bikeway access to Champagne Fountain Station via Saratoga Road.

14. Provides walk-in access from transit station to De Anza College (16,000 enrollment) and West Valley Business Park (800 employees).

15. Potential transfer station for feeder bus to West Valley College.

16. Provides direct walk-in access from transit station to Paul Masson Winery (200,000 annual visitors).

17. Potential transfer station for feeder bus to Vasona Lake County Park (over one million annual visitors).

18. Removal of orchards/cropland for station/parking lot or guideway.

19. Station serves two major limited-mobility groups heavily concentrated in surrounding area -- the elderly and households with no automobile.

20. Station serves large concentration of elderly in surrounding area.

Figure 53
VASONA CORRIDOR; OPPORTUNITIES AND CONSTRAINTS

1. At-grade transitway subject to periodic sheet flooding of perhaps a foot in depth.
2. Transit access to Del Mar Senior High School and adjoining school recreation grounds.
3. Bikeway access to Fruitvale Station via Meridian Avenue and Fruitvale Avenue.
4. Moderate development potential around station given existing character of area and supportive local development plans.
5. Transitway noise and visual impact on adjacent residences.
6. Potential impact of transitway on natural habitat and proposed open space associated with Los Gatos Creek which closely parallels the transitway.
7. Bikeway access to Campbell Station via Campbell Avenue.
8. Bikeway access to Bascom Station via Bascom Avenue.
9. Removal of orchards for station/parking lot.
10. Visual impact on surrounding area due to aerial transitway structures.
11. Transit access within one-half mile of San Jose City College.
12. Transit access within one-half mile of major shopping center.
13. Station serves three major limited-mobility groups heavily concentrated in surrounding area -- the elderly, low income families, and households with no automobile.
14. Station serves two major limited-mobility groups heavily concentrated in surrounding area -- the elderly and households with no automobile.

Figure 54

BLOSSOM HILL CORRIDOR; OPPORTUNITIES AND CONSTRAINTS

1. At-grade transitway subject to periodic sheet flooding of perhaps a foot in depth.
2. Moderate development potential around station given existing character of area and supportive local development plans.
3. Provides access to Oakridge Golf Course; transitway noise and visual impact on park setting.
4. Creek crossing requires precaution in design and construction to avoid degradation of water quality and aquatic ecosystem.
5. Potential barrier or access disruption of transitway intersecting Weyland Avenue bikeway.
6. Transitway impact on percolation ponds extending into the right-of-way area.
7. Guadalupe River crossing requires precaution in design and construction to avoid degradation of water quality and aquatic ecosystem.
8. Major development potential around station given existing character of area and supportive local development plans.
9. Potential barrier or access disruption of transitway intersecting Guadalupe Freeway bikeway corridor.
10. Provides access to two school playgrounds; transitway noise and visual impact on parklike setting.
11. Potential displacement and relocation of structures due to transitway.
12. Transitway intrusion through established residential neighborhood; transitway noise and visual impact on adjacent residences.
13. Bikeway access between and to Camden and Cambrian Park stations via Brannam Lane.
14. Structural impacts on transitway running parallel to Shannon Fault -- a potentially active fault.
15. Transitway noise and visual impact on adjacent residences.
16. Transitway physical intrusion and noise and visual impact on Cambrian Golf Course.
17. Transitway located in potential archeologic area as indicated by a Caltrans archeological investigation.
18. Significant opportunities for collateral development at station area, given available or vacant land.
19. Removal of orchards for station/parking lot.
20. Direct walk-in access from transit station to major shopping center.
21. Direct walk-in access from transit station to major health care facility.
22. Station serves large concentration of elderly in surrounding area.

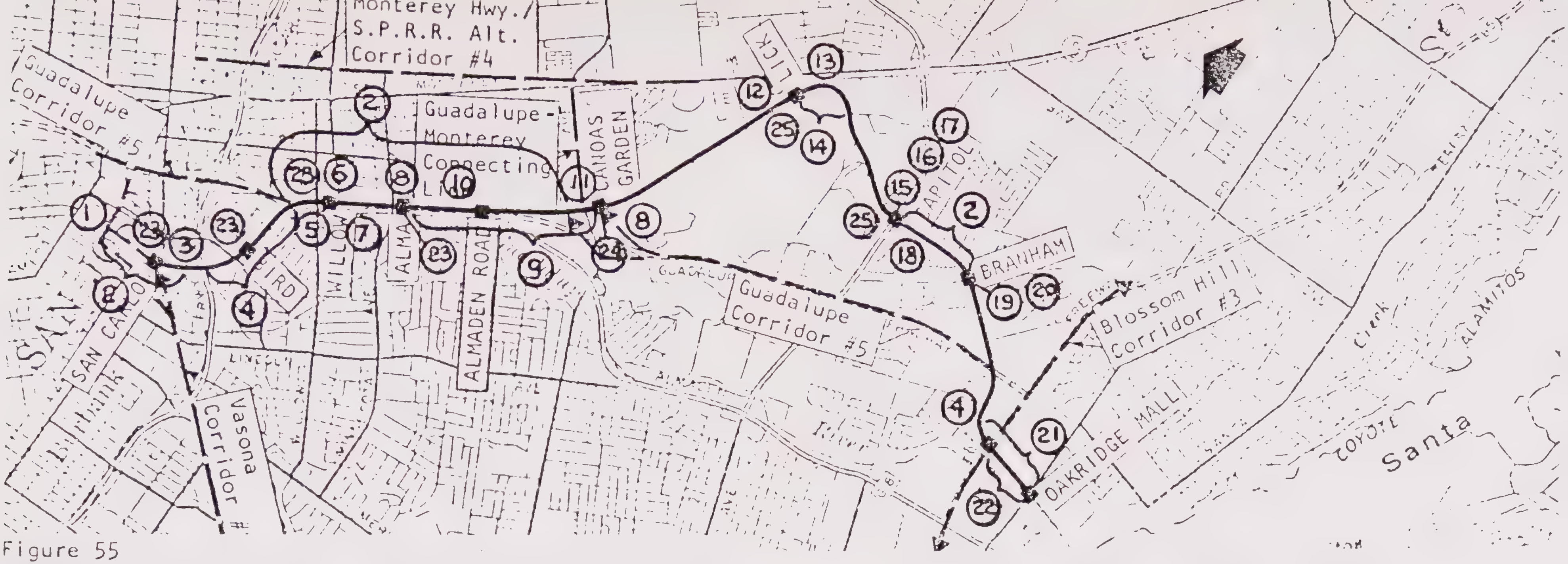

Figure 55
SP MAIN LINE/LICK CORRIDOR; OPPORTUNITIES AND CONSTRAINTS

1. Transfer to Peninsula passenger train service; San Jose CBD approximately one mile distant by feeder bus.

2. At-grade transitway subject to occasional sheet flooding of perhaps a foot in depth.

3. Los Gatos Creek crossing requires precaution in design and construction to avoid siltation and degradation of water quality and aquatic ecosystem.

4. Residences within 100 feet of transitway; noise and visual impacts. Potential removal of mature trees along the railroad tracks.

5. Guadalupe River crossing requires precaution in design and construction to avoid degradation of water quality and aquatic ecosystem. Opportunity for joing development of bikeway paralleling the river and transitway and connecting with transit stations.

6. Willow Station provides access to bikeway in Willow Street Corridor.

7. Alma Public Golf Course, adjacent to the alignment, would be accessible from Willow Station.

8. Potential collateral development and growth impact due to vacant land available in the area and policies favoring development here; major land use impact expected.

9. Potential archeological sites along alignment as indicated by Caltrans investigation.

10. Residences within 100 feet of transitway; noise and visual impacts.

11. Canoas Gardens Station provides access to bikeway in Curtner Avenue Corridor.

12. Displacement of some existing business required for transit station.

13. Potential collateral development, but not presently planned for intensive employment or housing.

14. Potential archeological sites as indicated by "A Plan for Conservation of Resources," an element of the Santa Clara County General Plan.

15. Capitol Station provides access to bikeway in Capitol Expressway corridor.

16. San Jose Vocational Center accessible by feeder bus from Capitol Station.

17. Significant opportunity for collateral development to increase housing and employment density to increase transit use; major land use impact expected.

18. Hames Park, adjacent to the alignment, would be accessible from Capitol Station.

19. Canoas Creek crossing requires care in design and construction to avoid flooding and siltation.

20. Vacant land available for collateral development, but land planned/zoned for low density housing.

21. Proximity to Guadalupe River affords opportunity for joing transitway/parkway development, including reservation of natural habitat as open space and provision of bicycle, hiking and equestrian trains paralleling the transitway alignment and connecting to transit stations. Connection can be provided with bikeway in Blossom Hill Corridor.

22. Potential collateral development and possible joint commercial/transit station construction; major potential land use impact in this area.

23. Station serves three major limited-mobility groups heavily concentrated in surrounding area -- the elderly, low income families, and households with no automobile.

24. Station serves two major limited-mobility groups heavily concentrated in surrounding area -- the low income families and households with no authomobile.

25. Station serves large concentration of low income families in surround-

Figure 56

MONTEREY HWY/SP RR ALT. CORRIDOR; OPPORTUNITIES AND CONSTRAINTS

1. San Jose CBD with 12,000 employees within one-half mile walking distance of the end of the line.

2. Access to San Jose State University with 27,000 students; transitway noise and visual impact in parklike setting.

3. Transitway noise and visual impact on adjacent residences; neighborhood intrusion with mixed traffic operation on two streets.

4. At-grade transitway subject to occasional "sheet" flooding of perhaps a foot in depth.

5. Potential archeological sites along entire length of Monterey Corridor as indicated by "A Plan for Conservation of Resources," an element of the Santa Clara County General Plan.

6. Bikeway access to Keyes Station via Story Road.

7. Vacant lots and industrial structures where redevelopment and rehabilitation could be pursued to intensify employment accessible via transit; redevelopment not presently planned by the City of San Jose.

8. Spartan Field, Muni Stadium, with 18,000 seats, Kelly Park and Zoo within walking distance of transit station.

9. Transit access to Langendorf Bakery, General Electric and Stauffer Chemical with combined employment over 5,000.

10. Bikeway access to General Electric station via Tully Road.

11. Transitway located within 100 feet of historic Holt House and corner of Oak Hill Cemetery.

12. Transit access to Santa Clara County Fairgrounds with over 1,000,000 visitors annually.

13. Approximately 15 acres of black walnut heritage trees in median and/or on the shoulder of the Monterey Highway would be removed by transitway development.

14. Senter Station provides feeder bus service to San Jose College Evergreen Campus and San Jose Vocational Institute; station also served by bikeway.

15. Potential moderate land use impact due to vacant land available and city policies favoring development here.

16. Transitway parallels designated Monterey bikeway between Senter and IBM; potential joint development.

17. Approximately five acres of orchard/cropland removed for transitway alignment and stations.

18. Frontier Village with 500,000 annual visitors within walking distance of Edenvale Station.

19. Vacant land available for intensive housing or employment development, but not presently planned or zoned for such.

20. Aerial structure prominent visual feature over highway and IBM parking lot.

21. At-grade transitway subject to occasional sheet flooding of perhaps a foot in depth.

22. Transit access to IBM with 7,000 employees; feeder bus to Fairchild and IBM Coyote with another 4,000 jobs.

23. Potential major development impact at the station.

24. Station serves three major limited-mobility groups heavily concentrated in surrounding area — the elderly, low income families and households with no automobile.

25. Station serves two major limited-mobility groups heavily concentrated in surrounding area — the elderly and low income families.

26. Station serves large concentration of low income families in surrounding area.

Figure 57
GUADALUPE CORRIDOR; OPPORTUNITIES AND CONSTRAINTS

1. San Jose CBD with 12,000 employees within two-thirds of a mile walking distance or shuttle bus ride from the end of the line; within six blocks of SP Station and Peninsula train service.

2. At-grade transitway subject to occasional sheet flooding of perhaps a foot in depth.

3. Los Gatos Creek crossing requires precaution in design and construction to avoid siltation and degradation of water quality and aquatic ecosystem.

4. Guadalupe River crossing requires precaution in design and construction to avoid siltation and degradation of water quality and aquatic ecosystem. Opportunity for joint development of bikeway paralleling the river and transitway and connection with transit stations.

5. Willow Station provides access to bikeway in Willow Street Corridor.

6. Alma Public Golf Course, adjacent to the alignment, would be accessible from Willow Station.

7. Potential archeological sites along the alignment as indicated by Caltrans investigation.

8. Moderate land use impact expected as a result of transitway development.

Transitway noise and visual impact on adjacent residences.

10. Canoas Gardens Station provides access to bikeway in Curtner Avenue Corridor.

11. Moderate potential for earthquake-induced landslide.

12. Canoas Ureek crossing requires care in design and construction to avoid flooding and siltation.

13. Capital Station provides access to bikeway in Capital Expressway Corridor.

14. San Jose Vocational Center is within walking distance of the Capital Station.

15. Vacant land available for collateral development to increase transit usage, but not presently planned or zoned for such.

16. Station serves three major limited-mobility groups heavily concentrated in surrounding area -- the elderly, low income families and households. with no automobile.

17. Station serves two major limited-mobility groups heavily concentrated in surrounding area -- low income families and households with no automobile.

18. Station serves large concentration of low income families in surrounding area.

In brief, analysis indicates no insurmountable land use, socio-economic or natural environmental constraint which would automatically preclude any particular mode -- baseline bus, bus preferential treatment, busway, light rail at-grade or light rail elevated. Likewise, no insurmountable problems were identified to preclude a particular corridor. There are sensitive locations in each corridor where mode difference could affect acceptability. And, each corridor presents a different set of circumstances to challenge transit system designers and avoid undesirable side effects.

CHAPTER VIII

ECONOMIC FEASIBILITY

INTRODUCTION

The purpose of economic analysis is to help determine the most effective investment of available resources in attaining a specified goal, in this case, improved public transportation service. In the private sector, the incentive to maximize profits tends to direct capital to the most efficient use. However, evaluating the economic viability of a public investment project is more difficult since public projects do not earn conventional profits which are indicative of correct investments. Other measures than profit must be used to determine the economic effectiveness and efficiency of the transit alternatives.

The most commonly used measurements of the economic feasibility of public projects fall into the broad category termed benefit-cost analysis. Benefit-cost analysis is designed to compare the benefits yielded to society as a whole with the resources required to implement and operate the system producing those benefits. The criterion to be used in the benefit-cost analysis of this report is the benefit-cost ratio.

The strengths and weaknesses of benefit-cost analysis are well documented in the technical literature. In order to provide as comprehensive an economic analysis as possible, supplementary measures were developed to be used as economic criteria together with the benefit-cost ratio. These additional criteria are transit efficiency measures which include various measures of costs on a per passenger and per passenger-mile basis. These criteria will be discussed and analyzed in the section following that on benefit-costs.

It is important to use constant dollars in economic analysis in order to assess a project's inherent worth. Although today's inflation rates are high, a change in the price level does not necessarily represent a real economic change in worth. By utilizing inflated dollar figures, the dollar value of the benefits would escalate. This, however, does not indicate a growth in benefits' real worth, but only their nominal worth, and has the effect of making an unprofitable project appear to be an attractive investment. The economic analysis therefore, was conducted in uninflated dollar terms in 1976 constant dollars. However, inflation was taken into account in the financial feasibility analysis, since actual cash flows rather than real worth are measured.

BENEFIT-COST MEASUREMENT

The basic steps for benefit-cost analysis are to:

- Define each alternative with sufficient precision to estimate costs and benefits.
- Identify and measure (in dollar terms) the benefits flowing from each alternative and the costs of implementing it.
- Calculate benefit-cost ratio to determine the relative economic viability of each alternative.

The benefit-cost measures developed in this analysis are based on a comparison of annual marginal benefits with the marginal annualized total costs. In accordance with the latest guidance received from UMTA officials, a "snapshot" comparison of 1990 annual benefits and costs was made. The benefit-cost ratio is expressed in the form of:

$$\text{Benefit-Cost Ratio} = \frac{\text{1990 Marginal Benefits}}{\text{1990 Marginal Annualized Total Costs}}$$

BENEFIT CALCULATIONS

Two forms of benefits were considered in this study: primary benefits which have traditionally been valued in studies of this type, and secondary benefits which, although real, are much more difficult to evaluate and quantify in terms of dollars. The primary benefits portion of the benefit-cost analysis consisted of the following:

Benefit 1: Constant Transit User Time Savings

This benefit accrues to the transit user who rode the system previous to implementation of rapid transit and realizes a time savings as a result of faster transit trip time. The value of time is generally considered to vary according to trip purpose, with work trips usually having a higher value of time than other trips. There are basically two methods of measuring the value of time that have been used in the past. The first approach, the one used in this study, measures the value of time for work trips only. The second approach employs an average value of time for all trips. The two approaches provide consistent results. The $4.50 value of time used in this analysis is based on a study done by Thomas C. Thomas, *The Value of Time For Passenger Cars: An Experimental Study of Commuter's Values*, modified to current price levels. This amounts to about two-thirds the average hourly wage in Santa Clara County.

Benefit 2: Non-Diverted Auto User Time Savings

This benefit measures the dollar value of user time saved by auto drivers continuing to use the highway system. The reduced traffic congestion, due to fewer vehicles remaining on the road as some auto users are diverted to transit, results in higher average speeds for those remaining vehicles. A value of time equal to that used in Benefit 1 applies.

Benefit 3: Diverted Auto User Automobile Operating and Maintenance (O&M) Cost Savings

This benefit measures the dollar savings resulting from reduced auto O & M costs for the new transit system rider diverted from his auto. A cost of $.10 per mile is used to value the reduction of operating and maintenance costs, reflecting only the variable costs associated with automobile operation. This figure is based on a study done by the U.S. Department of Transportation in 1974, "Costs of Operating an Automobile," modified to the current price level.

Benefit 4: Parking Cost Savings

By reducing the number of automobile trips, the transit system will cause a corresponding reduction in resources required for parking space to be realized. The total capital cost, a one-time investment of $5,000 for garage spaces and $1,600 per lot space, was annualized to produce an estimate of the yearly benefit. The annual operating and maintenance costs, valued at $75 for lot spaces and $120 for garage spaces, is added to the capital component to yield a total annual benefit.

Benefit 5: Reduced Highway Accidents

This benefit measures the value to society of reduced highway accidents as a result of reduced highway miles driven. The accident rates are Caltrans 1974 California accident rates. The cost associated with each type of accident shown below are Caltrans estimates of the total cost to society.

	Accident Rates Per 100 Million VMT	Cost Per Accident
Fatalities	2.2	$125,000
Injuries	73.0	4,000
Property Damage	96.0	1,200

The value of $125,000 represents the theoretical dollar value saving to society of each highway death avoided. This single value of death is not an attempt to capture the cost of loss of life, but rather is the average value of productive output foregone. The cost of injuries and property damage are based on the historical data of the average costs of these types of accidents.

Benefit 6: Commercial Vehicle Time Savings

The trucking industry realizes a benefit from implementation of a rapid transit system in the form of faster trips resulting from lower highway congestion. Since commercial vehicle drivers are being paid for the time spent on the road, the value of time for commercial vehicles is equal to the driver's wage. The California Trucking Association estimates the average California truck driver's wage at $8.00 per hour and this value was used in the economic analysis.

BENEFITS RESULTS

Five of the six quantified benefit elements calculated in Table 39 are proportional to the amount of auto trips diverted by the transit alternatives. This number is, in turn, closely proportional to new transit system trips attracted by the improved facility. Except for "Constant Transit User Time Savings," all benefit numbers are calculated as described earlier and reflect auto trips and miles avoided. The largest benefit in all cases except the bus preferential treatment is "Non-Diverted Auto Time Savings," calculated by estimating the degree of congestion reduction each alternative would produce. The second largest component is "Diverted Auto Operating and Maintenance Savings" due to the switch to transit.

The third largest dollar element in all guideway system benefits is "Constant Transit User Time Savings," calculated on the basis of faster trips for former local bus riders now on the improved transit system. "Parking Savings" are

Table 39
COMPONENTS OF PRIMARY ANNUAL BENEFITS
In Millions

	Base Case					Sub-Alternatives					
						Lower Cost		SP/PUC Requirements		Higher Cost	
	Baseline Bus	Bus Pref.	Expanded Bus	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail
Total System Annual Patronage	34.3	40.0	48.6	42.9	45.8	41.5	42.9	42.9	45.8	47.2	48.6
Incremental Patronage Over Baseline	--	5.7	14.3	8.6	11.5	7.2	8.6	8.6	11.5	12.9	14.3
Marginal 1990 Benefits Over Baseline Bus (1976 dollars)											
Non-Diverted Auto Time	--	--	7.55	7.05	8.81	5.87	7.05	7.05	8.81	10.10	11.28
Constant Transit Time	--	3.44	5.16	3.77	4.82	2.26	3.77	3.77	4.82	5.65	5.65
Commercial Vehicle Time	--	--	1.75	1.63	2.04	1.36	1.63	1.63	2.04	2.34	2.61
Diverted Auto O & M	--	3.20	5.15	4.80	6.01	4.00	4.80	4.80	6.01	6.89	7.69
Parking Savings	--	2.08	4.42	3.00	3.75	2.50	3.00	3.00	3.75	4.20	4.80
Accident Reduction	--	0.22	0.35	0.33	0.41	0.27	0.33	0.33	0.41	0.47	0.52
Total Benefits	--	8.94	24.38	20.58	25.84	16.26	20.58	20.58	25.84	29.75	32.55

the capital and operating savings from the estimated number of spaces avoided in each alternative. "Commercial Vehicle Time Savings" is directly proportional to "Non-Diverted Auto Time Savings," based on the percentage of peak period freeway commercial vehicle trips. "Accident Reduction" is proportional to auto miles not driven and thus to "Diverted Auto O & M Savings."

The benefits for the "SP/PUC Requirements" sub-alternative are the same as for the base case. In all cases, light rail has greater benefits than busway. The benefits for more costly systems are usually greater than for less expensive ones. Total benefits for transitway alternatives vary by a maximum of 100 percent. Variations between busway and light rail at a given investment level are about 25 percent.

The benefits for the bus preferential treatment alternative require some additional discussion. The total benefits of the bus preferential treatment scheme are low because of the lack of non-diverted auto time savings. Whereas in the other alternatives, there is significant quantifiable decrease in peak period freeway congestion due to the reduced number of trips (diverted to a newly constructed facility), in this alternative the transit system decreases existing capacity by pre-empting auto lanes for the exclusive use of buses. The signal pre-emption and freeway entrance ramp-metering devices will cause additional delay to non-diverted auto users. The net congestion effect of reducing the number of autos on the road through diversion to transit while at the same time reducing the number of lanes available for use by autos is not certain. It has been assumed for the purposes of this study that the two conditions will cancel each other, producing approximately zero time change to the constant auto driver as a result of preferential bus treatment implementation.

The "Constant Transit User Time Savings" in the Expanded Local Bus Service result from a systemwide reduction in headways and hence average waiting time. Because all former transit users benefit from the systemwide expansion of service, this benefit is larger than most other corridor-type constant transit time benefits.

In some studies another benefit which would accrue to the auto driver diverted to transit is quantified; namely diverted auto user time savings. In this study, under most alternatives, people will not realize a time savings by diverting to transit. However, they do benefit by being able to read or relax, which they could not do while driving. It can be assumed that they realize a positive benefit not measurable by valuing time savings. Therefore, this benefit was not calculated in the benefit-cost analysis.

POTENTIAL ADDITIONAL BENEFITS

The secondary benefits shown in Table 40 were included in the supplemental benefit-cost analysis. They consist of:

Benefit A: Containment of Urban Sprawl

One of the high priority goals at all levels of government is to check urban sprawl. As such, transit implementation's contribution to this end is a very important benefit. However, it is not an easily quantified one. One way of measuring reduction in urban sprawl is by valuing the resulting savings in water and sewer line costs. Through a more compact development form, fewer acres would be required to accommodate increases in population and employment, thereby requiring fewer trunk lines.

Santa Clara County will experience significant growth between now and 1990. Within the five-corridor area, an increase of 164,000 people and 48,000 jobs will occur. Under the current low density conditions of 15 persons/20 jobs per acre, a total of 13.3 thousand new acres would have to be developed. If land use and zoning controls permitted, it is realistic to assume that in the transit corridors, a density of 30 persons or 40 jobs per acre could be easily accommodated. With this average density, a savings of 6.7 thousand acres could be realized.

Table 40
POTENTIAL ADD-ON BENEFITS
In Millions of 1976 Dollars

Marginal 1990 Benefits	Base Case					Sub-Alternatives					
						Lower Cost		SP/PUC Requirements		Higher Cost	
	Baseline Bus	Bus Pref.	Expanded Bus	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail
Reduction in Urban Sprawl Infrastructure Savings	--	--	--	4.29	4.29	4.29	4.29	4.29	4.29	4.29	4.29
Reduction In Auto Ownership	--	1.43	3.56	2.14	2.85	1.78	2.14	2.14	2.85	3.21	3.57
Non-Work Trip Time Savings											
• Constant Transit User	--	1.29	3.54	1.40	1.80	0.85	1.40	1.40	1.80	2.11	2.11
• Constant Auto User	--	--	1.26	1.18	1.47	0.98	1.18	1.18	1.47	1.68	1.88
Total Potential Additional Benefits	--	2.72	8.36	9.01	10.41	7.90	9.01	9.01	10.41	11.29	11.85

The cost associated with developing this number of acres is considerable. Based on a similar study made by the Comprehensive Planning Organization (San Diego), the cost per acre of the infrastructure totals $13,000 in 1974 dollars. Escalated to 1976 dollars, this would equal $15,000 per acre for a total savings of $100 million. The annualized savings assuming a 25-year life and seven percent capital recovery factor equals $8.58 million. There will be additional annual savings related to maintenance costs avoided as a result of not constructing the trunk lines and streets, but these have not been estimated.

It is not suggested that the changes will occur exactly as described above. Much of the area's development will be independent of transit system expansion. However, analyses conducted in other cities (San Diego, Denver, Toronto) do show a relationship between containment of urban sprawl and fixed guideway transit development if other conditions are favorable and appropriate actions are undertaken by the governments involved. Therefore, it is assumed that 50 percent of the savings, or $4.29 million might be attributed to guideway transit. This benefit will only result from transitway implementation. It should be noted that while the dollar value of this benefit is unclear for rail transit, it is even less sure for busway transit. However, for the purposes of this analysis, it is assumed that the benefit will accrue to both light rail transit and bus guideway alternatives.

Benefit B: Reduction in Automobile Ownership

With 50 percent of the Santa Clara County households owning more than one car, it is assumed that 50 percent of diverted transit riders who are members of multi-car families will forego the purchase of an additional automobile. The cost of each automobile has been set at $4,000 with an estimated life of ten years. The annualized cost of each vehicle at seven percent discount rate would then equal $570 per year.

Benefit C: Time Saved, Non-Work Trips

The value of work trips has already been calculated using a value of $4.50 per hour for the time of persons using the transit system. Traditionally,

time saved on other trips has not been valued, on the assumption that such trips are discretionary and the time spent in making them is not an important factor. It is probably more correct to say that for such trips time is of less economic value than for work trips. The assumption has been made for this study that the value of time for non-work trips is 50 percent of the commuter figure, or $2.25 per hour for purposes of assessing potential add-on benefits.

COST CALCULATIONS

Capital costs by major system component were developed as described in Chapter IV. To calculate annualized capital costs, a capital recovery factor was applied to each of the major components.

The formula for the capital recovery factor is as follows:

$$CRF = \frac{i(1 + i)^n}{(1 + 1)^n - 1}$$

where: i = discount rate
n = economic life of capital investment (in years)
CRF = capital recovery factor

In view of the current lack of agreement as to what constitutes a proper discount rate, rates of 4, 7 and 10 percent were used in the capital recovery factors for each of the components listed below, assuming the corresponding economic life. The annualized (annual equivalent) capital cost of each component is the product of its total capital cost and the appropriate capital recovery factor.

System Element	Economic Life
Guideways	40
Stations and station parking	40
Trackwork	40
Power collection and distribution	40
Control and communication	40
Maintenance and storage facilities	40
Right-of-way	40
Street construction, railroad track and utility relocation	40
Contingency and agency costs	40
Rail vehicles	25
Used vehicles (rail)	20
Buses	12

Table 41 presents annualized capital costs for all alternatives as used in benefit cost and transit efficiency measures. Undiscounted totals come from engineering cost totals.

The 4, 7 and 10 percent discounted components and totals show the effect of the vehicle and durable capital lifetime because 12, 25 and 40 year capital recovery factors are used respectively for buses, light rail cars and other facilities. For any given level (Base Case, Lower Cost, SP/PUC, Higher Cost) light rail is more costly -- as it was in undiscounted terms. The relative vehicle lifetime, however, lowers the difference between bus fleet and light rail fleet, particularly compensating the significant difference in their purchase cost. In the Base Case, for example, undiscounted light rail vehicles cost three times as much as buses, but only twice as much on an annual basis when discounted at seven percent.

Annualized capital cost is only part of the total cost picture. Equally, and sometimes even more important, are annual operating and maintenance costs.

Table 41
ANNUALIZED CAPITAL COSTS
Incremental Annual Costs based on 1990 Patronage; Millions of 1976 Dollars

	Base Case					Sub-Alternatives					
						Lower Cost		SP/PUC Requirements		Higher Cost	
	Baseline Bus	Bus Pref.	Expanded Bus	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail
Undiscounted Total											
Durable Capital	26.98	27.03	25.72	161.10	233.78	153.05	205.74	189.56	260.23	262.92	314.21
Vehicle Capital	41.28	12.60	40.00	13.13	33.75	13.13	4.69	13.13	33.75	13.13	33.75
Sum	68.26	39.63	66.72	174.23	267.53	166.18	210.43	202.69	293.98	276.05	347.96
7% Discount Rate											
Durable Capital	2.10	2.03	1.92	12.08	17.54	11.48	15.42	14.22	19.54	19.72	23.57
Vehicle Capital	5.28	1.59	5.11	1.65	2.90	1.65	0.44	1.65	2.90	1.65	2.90
Sum	7.38	3.62	7.03	13.73	20.44	13.13	15.86	15.87	22.44	21.37	26.47
4% Discount Rate											
Durable Capital	1.42	1.37	1.29	8.14	11.81	7.73	10.39	9.58	13.16	13.28	15.87
Vehicle Capital	4.47	1.34	4.33	1.40	2.16	1.40	0.34	1.40	2.16	1.40	2.16
Sum	5.89	2.71	5.62	9.54	13.97	9.13	10.73	10.98	15.32	14.68	18.03
10% Discount Rate											
Durable Capital	2.86	2.76	2.62	16.47	23.91	15.65	21.03	19.38	26.64	26.89	32.13
Vehicle Capital	6.15	1.85	5.96	1.93	3.72	1.93	0.55	1.93	3.72	1.93	3.72
Sum	9.01	4.61	8.58	18.40	27.63	17.58	21.58	21.31	30.36	28.82	35.85

These were calculated as explained in Chapter VI. As Table 42 shows, Base Bus annual operating cost is $38.6 million, much greater than its mere $7.38 million annualized capital cost at seven percent. In all transitway cases, busway operating costs are almost 30 percent higher than light rail sub-alternatives. The additional annual operating cost of $34 million of the expanded local bus system over the $38.6 million of the base bus system makes that system much less attractive than any other alternative from the viewpoint of annual operating costs.

To represent total cost to the Santa Clara County Transit District of each system, the required "Purchase of Service" agreement transfer monies to the Southern Pacific Transportation Company are shown. These costs are actually "price paid" rather than the "economic cost" of providing such service. It is assumed that SP would accept such a payment by the agency for each passenger carried and its price was calculated as explained earlier in this report.

The marginal annual total cost as used in the benefit-cost calculation is the sum of the annualized capital cost (for each of the different discount rates used) and the 1990 operating cost. Again, all costs are expressed in terms of 1976 dollars. The marginal annual total costs for each alternative and sub-alternative can be seen in Table 42.

BENEFIT-COST CALCULATIONS

The benefit-cost ratios for each of the transit mode alternatives and the design standards/service level sub-alternatives without the potential add-on benefits can be seen in Table 43. It is important to note that none of these has a ratio greater than 1.0 (the point at which economic benefits equal economic costs and thus achieve a "break-even" point) for the 7 percent and 10 percent discount rates. At 4 percent, almost all but the Preferential Bus Treatment and Expanded Local Bus Service alternatives benefit-cost ratios become slightly greater than 1.0.

Table 42
MARGINAL ANNUAL SYSTEM COSTS
Annual Costs Based on 1990 Patronage; Millions of 1976 Dollars

	Base Case					Sub-Alternatives					
						Lower Cost		SP/PUC Requirements		Higher Cost	
	Baseline Bus	Bus Pref.	Expanded Bus	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail
Incremental O&M	38.60	9.30	34.00	7.30	5.50	6.40	5.85	7.30	5.50	7.80	6.00
Purchase of SP Service	--	2.30	--	3.00	3.20	2.80	3.00	3.00	3.20	3.40	3.40
Sub-Total	38.60	11.60	34.00	10.30	8.70	9.20	8.85	10.30	8.70	11.20	9.40
Annual Capital Costs											
at 7% Discount	7.38	3.62	7.03	13.73	20.44	13.13	15.86	15.87	22.44	21.37	26.47
at 4% Discount	5.89	2.71	5.62	9.54	13.97	9.13	10.73	10.98	15.32	14.68	18.03
at 10% Discount	9.01	4.61	8.58	18.40	27.63	17.58	21.58	21.31	30.36	28.82	35.85
Total Annual Incremental Costs											
at 7% Discount	45.98	15.22	41.03	24.03	29.14	22.33	24.71	26.17	31.14	32.57	35.87
at 4% Discount	44.49	14.31	39.62	19.84	22.67	18.33	19.58	21.28	24.02	25.88	27.43
at 10% Discount	47.61	16.21	42.58	28.74	36.33	26.78	30.43	31.61	39.06	40.02	45.25

Table 43
1990 BENEFIT-COST RATIOS WITHOUT AND WITH POTENTIAL ADDITIONAL BENEFITS

	Base Case					Sub-Alternatives					
						Lower Cost		SP/PUC Requirements		Higher Cost	
Benefits/Costs*	Baseline Bus	Bus Pref.	Expanded Bus	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail
Without Potential Additional Benefits											
7% Discount Rate											
Annual Benefits	--	8.94	24.38	20.58	25.84	16.26	20.58	20.58	25.84	29.75	32.55
Annualized Costs	45.98	15.22	41.03	24.03	29.14	22.33	24.71	26.17	31.14	32.57	35.87
Benefit-Cost Ratio	--	0.59	0.59	0.86	0.87	0.73	0.83	0.77	0.83	0.91	0.91
4% Discount Rate											
Annual Benefits	--	8.94	24.38	20.58	25.84	16.26	20.58	20.58	25.84	29.75	32.55
Annualized Costs	44.49	14.31	39.62	19.84	22.67	18.33	19.58	21.28	24.02	25.88	27.43
Benefit-Cost Ratio	--	0.62	0.62	1.04	1.14	0.89	1.05	0.97	1.08	1.15	1.19
10% Discount Rate											
Annual Benefits	--	8.94	24.38	20.58	25.84	16.26	20.58	20.58	25.84	29.75	32.55
Annualized Costs	47.61	16.21	42.58	28.74	36.33	26.78	30.43	31.61	39.06	40.02	45.25
Benefit-Cost Ratio	--	0.55	0.57	0.72	0.71	0.61	0.68	0.65	0.66	0.74	0.72
With Potential Additional Benefits											
7% Discount Rate											
Annual Benefits	--	11.66	32.74	29.59	36.25	24.16	29.59	29.59	36.25	41.04	44.22
Annualized Costs	45.98	15.22	41.03	24.03	29.14	22.33	24.71	26.17	31.14	32.57	35.37
Benefit-Cost Ratio	--	0.77	0.80	1.23	1.24	1.08	1.20	1.13	1.16	1.26	1.24

* Benefits and costs are marginal; expressed in millions of 1976 dollars

It can also be seen that both transitway systems appear consistently superior on economic grounds to the lower capital cost bus systems. The data in Table 43 also indicates that under a wide variety of assumptions the benefit-cost ratio for the light rail systems is equal to or slightly higher than the busway system. Lower discount rates tend to favor the more capital intensive light rail concept; higher discount rates favor the busway. It should also be noted that the benefit-cost ratios for the more expensive sub-alternatives are higher than those of the cheaper systems.

At the primary discount rate of this analysis, seven percent, there is an almost uniform proportionality of benefits to costs, resulting in light rail being approximately equal to busway, or slightly preferred. The level of advantage of LRT ranges from 0.01 in the Base Case and zero in the higher cost case to 0.10 in the lower cost case. These small differences are well within the margin of error of the analysis. Thus the benefit-cost ratios at seven percent discount rate should be considered to economically equate light rail and busway systems.

The interpretation of the small differences in ratios between different investment levels of light rail/busway pairs must allow statistical error in all component inputs. Because the pairs are so relatively close, no mode choice should be made on the basis of benefit-cost results between busway and light rail. Other significant factors must enter into the decision process. Even the inter-level difference between lower cost busway (0.73) and higher cost light rail (0.91) should not imply the latter is a definitely superior investment.

The uniformity of benefit-cost results is not due to all systems analyzed being identical, but rather to the proportionality of benefits independently to total costs. Total annualized marginal costs range from $22.33 million for the lower cost busway to $35.87 million for the higher cost light rail, a difference of over 50 percent. But the benefits difference between the same pair jumped from $16.26 million to $32.55 million, almost 100 percent, resulting in the benefit-cost ratio growth from 0.73 to 0.91 mentioned above.

Just as pronounced as the similarity between the busway and light rail alternatives in economic terms is their mutual superiority over both the bus preferential treatment and expanded local bus systems. Both of the latter have benefit-cost ratios less than 0.6, well below the 0.9 of the base case busway and light rail systems. The low ratios are due to two different sets of circumstances.

The bus preferential treatment has a very low capital investment, less than any other system. Its annual operating cost is roughly comparable to busway operating costs. Yet the annual benefits, only about one-third of those for base case light rail, make the benefit-cost ratio small because of the small numerator. It is a low cost system with disproportionately lower benefits.

The expanded local bus system, on the other hand, has annualized capital costs only half of the base case busway but annual operating costs of greater than three times the busway. Thus, although the benefits are greater than for the base case busway, the high system annualized cost makes the benefit-cost ratio low because of the high denominator. The system has very sizable operating costs, not offset by proportionately higher benefits.

Because the gap between the ratios for either of the two non-transitway bus systems and the busway and light rail systems remains large, both against sub-alternatives and at different discount rates, it is concluded that neither one is nearly as economically viable as the busway or light rail systems, bus preferential treatment being inferior because of low benefits while expanded local bus fails due to high operating cost.

All of the sub-alternatives, as well as the base case are relatively equally viable because their benefit-cost ratios are generally similar. Although total system costs vary 50 percent and total benefits vary 100 percent across the light rail and busway alternatives, the ratios are close because of proportionality of benefits and costs. Furthermore,

except for the "SP/PUC Requirements" sub-alternative, the ratios are roughly proportional to total investment. Thus the "Lower Cost" pair has inferior benefit-cost ratios to the "Base Case" which is in turn inferior to the "Higher Cost" case. This suggests increasing returns on investment, but as stated earlier, slight differences in benefit-cost ratios should not be used as a basis for decision-making.

BENEFIT-COST ANALYSIS INCLUDING POTENTIAL ADD-ON BENEFITS

One of the shortcomings of benefit-cost analysis as a tool in determining the economic viability of a transit system is that it can account only for those benefits which are directly quantifiable in dollar terms. Many of the benefits that will accrue to transit development, however, are either difficult or impossible to assign a dollar value. To the extent that these benefits exist but are not counted, the benefit-cost ratio will give a low estimate of the economic viability of a system and hence may prompt the decision-makers to reject an alternative with a benefit-cost ratio something less than one when the total of the non-quantified and quantified benefits together far exceed the costs.

In an effort to make the benefit-cost ratio a more complete picture of economic viability, several cities have attempted to quantify benefits which have previously not been included in traditional benefit-cost analysis. For example, recent transit evaluations in both San Diego and Denver have included in their benefit-cost analysis such measures as land use benefits, water and sewer infrastructural cost savings, and automobile ownership reduction. A study in Los Angeles also quantified these plus an additional benefit of non-work trip time savings.

Admittedly these benefits -- while often very real consequences of transit implementation -- are not easy to quantify and, more importantly, are subject to a complex array of both transit and non-transit related public policies, controls and regulations, as well as consumer attitudes and

behavior. Nevertheless, they do provide an indication of what the magnitude of benefit-cost ratios might be with a more complete accounting of benefits. Therefore, a dollar value has been placed judgmentally on infrastructure savings resulting from reduction in urban sprawl, reduction in second and third automobile and non-work trip time savings in Santa Clara County, as described earlier in this chapter. This material should be considered as a supplement to the traditional benefit-cost analysis.

Results of Analysis

Benefit-cost measurement including potential add-on benefits are shown in Table 43. With the inclusion of the additional benefits, all transitway alternatives appear to be at least marginally attractive investments with benefit-cost ratios ranging from 1.08 to 1.26 at a seven percent discount rate. The non-transitway alternatives -- the bus preferential treatment and the expanded local bus alternatives -- are far inferior with ratios of 0.77 and 0.80 respectively.

Any of the transitway alternatives could be selected from an economic point of view. The base case busway and light rail alternatives are essentially equal with benefit-cost ratios differing by only 0.01. Between the base and the sub-alternatives, there are slight differences. While the higher cost alternatives are essentially equal to the base case, the SP/PUC alternatives and the lower cost ratios are somewhat lower, although still being in the realm of economic viability. It would not be possible to select a system solely on the basis of this analysis with such a close grouping of ratios between the transitway alternatives. On the other hand, the non-transitway alternatives might be rejected on the basis that they appear considerably inferior from the benefit-cost analysis point of view.

In comparison with the traditional benefit-cost ratios, the results of this analysis show the impact of placing a value on difficult-to-quantify benefits. In the traditional analysis, no alternative achieved a benefit-cost ratio greater than one at a seven percent discount rate, indicating

only marginal viability at best. Including the add-on benefits, the ranking of alternatives is the same but a greater economic viability is apparent.

It is emphasized that the results from these ratios including additonal benefits should be interpreted with caution. They are presented to suggest the effect of including the more difficult to quantify benefits associated with transit development. The actual measures should be regarded as indicative rather than conclusive.

ECONOMIC EFFICIENCY MEASURES

Transit efficiency measures are criteria for evaluating alternative transit systems in terms of their economic efficiency in attracting and moving passengers. The transit efficiency analysis is concerned with only the quantity of direct transit usage and service produced by the alternatives and the direct costs associated with providing these. The transit efficiency measures are used for comparing the alternatives with respect to how much they cost per unit of transit productivity; i.e., cost per passenger carried and per passenger-mile served. Thus, costs and productivity are the only aspects of the alternative systems considered in the transit efficiency analysis.

The productivity and costs used in the transit efficiency analysis are based on the patronage levels forecasted for 1990. Thus, the transit efficiency analysis is a "snapshot" in time; that is, the measures depict the efficiency of the transit alternatives at a given patronage level. The relative transit efficiency of each alternative may vary significantly at other patronage levels. However, no attempt is made to measure the efficiency at different patronage levels or to determine the cumulative efficiency over the life of the transit system. The light rail system is particularly capable, for example, of absorbing additional patrons with

only minimal cost increases, whereas bus-oriented systems generally show cost increases proportional to patronage increases. This "snapshot" approach is consistent with suggestions of UMTA personnel concerning the approach to be followed in the total analysis and evaluation of alternatives.

Transit efficiency measures provide one means of assessing the economic effectiveness of a transit investment. When viewed together with the results of the benefit-cost analysis, they provide as comprehensive as possible a picture of the relative economic effectiveness of the alternatives.

Review of the various system cost-related transit efficiency measures presented in Table 44 shows that light rail generally has a moderate advantage over the busway system, not only under the base case assumptions, but also in the sub-alternatives. Light rail is about the same as busway in terms of total system cost per passenger and per passenger-mile, superior to busway in incremental total cost, system and incremental O & M cost, and inferior only in system and incremental capital cost. Both non-transitway bus systems are superior to either busways or light rail for the total system capital cost per passenger and per passenger-mile and inferior in respect to O & M cost measures and subsidy required measures.

Capital and Operating Costs

As can be seen in Table 44, there is a nearly direct trade-off in effectiveness between light rail and busway, the former being preferred in all O & M cost categories and the latter being preferred in all annualized capital categories.

Considering annualized system capital cost, it is noted that base case light rail costs $0.61 per passenger, 12 cents more than the busway. The 24 percent difference decreases to 12 percent when marginal capital cost is measured, because the light rail system gains more passengers than the busway. The differences per passenger-mile are smaller because the light rail system serves more passenger-miles.

TRANSIT ECONOMIC EFFICIENCY MEASURES -- SYSTEM COSTS

	Base Case					Sub-Alternatives					
						Lower Cost		SP/PUC Requirements		Higher Cost	
	Baseline Bus	Bus Pref.	Expanded Bus	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail
Total System Annual Passenger Trips (millions)	34.3	40.0	48.6	42.9	45.8	41.5	42.9	42.9	45.8	47.2	48.6
Total System Annual Passenger Miles (millions)	154.4	208.8	218.8	236.0	256.0	234.5	236.0	236.0	256.0	266.0	276.0
Incremental Annual Passenger Trips (millions)	--	5.7	14.3	8.6	11.5	7.2	8.6	8.6	11.5	12.9	14.3
Incremental Annual Passenger Miles (millions)	--	54.3	64.4	81.5	101.5	80.1	81.5	81.5	101.5	111.5	121.6
Annual Cost in 1976 Dollars per 1990 Passenger-Trip and 1990 Passenger-Mile											
Total System Capital Cost/Passenger	$0.21	$0.27	$0.30	$0.49	$0.61	$0.49	$0.54	$0.54	$0.65	$0.61	$0.70
Total System Capital Cost/Passenger-Mile	0.05	0.05	0.07	0.09	0.11	0.09	0.10	0.10	0.12	0.11	0.12
Incremental Over Base Marginal Cost/Passenger	--	0.63	0.49	1.60	1.79	1.84	1.85	1.85	1.96	1.66	1.85
Marginal Cost/ Passenger Mile	--	0.07	0.11	0.17	0.20	0.16	0.19	0.19	0.22	0.19	0.22
Total System O+M Cost/ Passenger	1.13	1.34	1.56	1.22	1.11	1.23	1.18	1.22	1.11	1.13	1.06
Total System O+M Cost/ Passenger-Mile	0.25	0.26	0.35	0.22	0.20	0.22	0.22	0.22	0.20	0.20	0.19
Incremental Over Base Marginal Cost/Passenger	--	2.03	2.38	1.20	0.76	1.29	1.03	1.20	0.76	0.87	0.66
Marginal Cost/ Passenger-Mile	--	0.21	0.53	0.13	0.09	0.11	0.11	0.13	0.09	0.11	0.08
Total System Cost Total Cost/Passenger	$1.34	$1.61	$1.86	$1.71	$1.72	$1.72	$1.72	$1.76	$1.76	$1.74	$1.76
Total Cost/Passenger-Mile	0.30	0.31	0.42	0.31	0.31	0.31	0.32	0.32	0.32	0.31	0.31
Incremental Over Base Marginal Cost/Passenger	--	2.66	2.87	2.80	2.55	3.13	2.83	3.05	2.72	2.53	2.52
Marginal Cost/ Passenger-Mile	--	0.28	0.64	0.30	0.29	0.27	0.30	0.32	0.31	0.30	0.30

Considering the sub-alternatives, the relative mode ranking and rough percentages remain the same. For the total system capital figures, busway has less advantage over light rail in all alternatives other than base case. In the incremental measurement, all sub-alternatives appear inferior to the base case pair, but in the same order. It is notable that in the lower cost case the marginal capital cost per passenger is the same for light rail and busway because light rail capital costs are cut more than busway costs, yet result in less deterioration of patronage.

On the other hand, because of its greater labor-efficiency and higher patronage potential, light rail clearly leads busway in the base case as well as all sub-alternatives with respect to operating cost-effectiveness. Most notably, the incremental operating cost per passenger-trip of the busway is $1.20 or 44 cents (58 percent) higher than the $0.76 per passenger figure for the light rail alternative.

Total System Costs

Total system costs are the traditional "bottom line," the measure of overall network efficiency. In the base case, the light rail at $1.72 per passenger trip is virtually identical to the busway alternative at $1.71. Both have a cost of $0.31 per passenger-mile. This means that either guideway system combined with the 516-bus base bus operation will be equally productive. The reason both are higher than the $1.34 per passenger-trip of the base bus is the longer average trip length (7.0 miles for guideway passengers vs. 4.5 miles for local bus passengers). In fact, the cost per passenger-mile of $0.31 is essentially equal to $0.30 per passenger-mile of the base bus, reflecting the average trip length difference.

It is obvious that the sub-alternative assumptions are almost identical to but generally slightly less efficient than the base case pair. Only in the higher cost case is the incremental total cost per passenger slightly lower than the base case value for light rail and moderately lower for busway. This results from the near convergence of service levels between

busway and light rail in the higher cost case as both transitways are nearly fully grade separated. In this circumstance the system and incremental costs for both output variables are almost identical for busway and light rail. The reason that base case light rail is cheaper incrementally ($2.55 per passenger trip) than busway ($2.80) is light rail's significantly larger passenger gain of 40,000 daily versus 30,000 daily for the busway. This difference is analogous in all pairs except the higher cost case already discussed.

In terms of total system cost, the bus preferential treatment alternative ranks well. Its $1.61 per passenger-trip is lower than any transitway alternative and $0.31 per passenger-mile is identical to the guideway system average. But it must be remembered that this is a "low benefit" system, only serving 20,000 new daily riders. This is partially reflected in Table 44 by the incremental total cost of 28 cents per passenger-mile, only slightly less than that of the guideway figures, and $2.66 per marginal passenger-trip which is higher than base case light rail and both transitway modes with the higher cost assumption.

Expanded local bus has a significant economic disadvantage to all other alternative improvements except in initial capital cost. The total system cost of $1.86 per passenger and $0.42 per passenger-mile is worse than any other alternative. Its incremental cost total of $2.87 per passenger-trip and $0.64 per passenger-mile is worse by a large margin except for lower cost and SP/PUC busways. These are a direct result of the very high operating cost and short average trip length (4.5 miles, all trips).

Subsidy Costs

Subsidy requirements, which equal total operating cost minus fare revenue represent a significant ongoing cost of the system which is not paid for by transit users and must be covered by the local, state and Federal government. As such, subsidy requirement measurements on a per passenger and per passenger mile basis are an important indication of the efficiency of a transit system. This data is presented in Table 45.

Table 45
TRANSIT EFFICIENCY -- SUBSIDY REQUIREMENTS
Annual Cost in 1976 Dollars per 1990 Passenger-Trip and Passenger-Mile

	Base Case					Sub-Alternatives					
						Lower Cost		SP/PUC Requirements		Higher Cost	
	Baseline Bus	Bus Pref.	Expanded Bus	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail
System Subsidy Requirements*											
O & M Costs (incl. SP Service)	38.60	53.60	76.00	52.30	50.70	51.20	50.85	52.30	50.70	53.20	51.40
Fare Revenues	5.83	6.80	8.26	7.29	7.78	6.92	7.29	7.29	7.78	8.06	8.26
Subsidy Required	32.77	46.80	67.74	45.01	42.92	44.28	43.56	45.01	42.92	45.14	43.14
Subsidy/Passenger	0.96	1.17	1.39	1.05	0.94	1.07	1.01	1.05	0.94	0.96	0.89
Subsidy/Passenger-Mile	0.21	0.22	0.31	0.19	0.17	0.19	0.18	0.19	0.17	0.17	0.16
Incremental Subsidy**											
O & M Costs (incl. SP Service)	--	11.60	34.00	10.30	8.70	9.20	8.85	10.30	8.70	11.20	9.40
Fare Revenues	--	0.97	2.43	1.46	1.95	1.09	1.46	1.46	1.95	2.23	2.43
Subsidy	--	10.63	31.57	8.84	6.75	8.11	7.39	8.84	6.75	8.97	6.97
Subsidy/Passenger	--	1.86	2.21	1.03	0.59	1.13	0.86	1.03	0.59	0.70	0.49
Subsidy/Passenger-Mile	--	0.20	0.49	0.11	0.07	0.10	0.09	0.11	0.07	0.08	0.06

Note: All Figures are Millions of Dollars except per Passenger and per Passenger-Mile Figures.

* Baseline bus costs and revenues included in all alternatives.

** Costs and revenues are the costs/revenues accrued as a result of alternative implementation. These figures do not include base bus figures.

Base case light rail has a ten percent advantage over busway ($0.94 per passenger vs. $1.05) because it both carries more passengers and costs less to operate. There is a similar difference in subsidy per passenger-mile for the total system. Actually, the significant subsidy difference between the modes is obscured in the system totals because of the domination of the total base bus subsidy ($32.77 million annually) over the incremental subsidy of $6.75 million for light rail and $8.84 million for busway. This difference is better shown by the incremental subsidy of $0.59 per passenger trip in light rail versus $1.03 for busway, or 75 percent greater than light rail. The difference is 57 percent in terms of cost per passenger-mile. Thus, the light rail alternative has a major subsidy advantage. In comparison to the committed base bus system, the busway would produce a 10% greater system total subsidy per passenger while reducing its subsidy per passenger-mile by two cents. The light rail system will reduce total system subsidy required both per passenger-trip and per passenger-mile.

From the subsidy standpoint, shown in Table 45, the bus preferential treatment alternative performs poorly. Because it is a labor-intensive, high operating cost system with only moderate patronage, system subsidy cost per passenger is $1.17, ten percent worse than the poorest transitway case (lower cost busway). But in terms of incremental subsidy, it requires $1.86 per passenger, 215 percent higher than base case light rail and 65 percent worse than the least attractive transitway option. The prospect of the exceedingly high continuing subsidy makes bus preferential treatment unattractive, despite its low capital cost of 27 cents per passenger-trip, only 44 percent of base case light rail.

It should be noted that all sub-alternatives have subsidy measures similar to the base case and that the ranking preference of light rail over busway never changes. The meeting SP requirements alternative has identical output to the base case because it has the same patronage and operating costs as the base case, and only a higher initial capital investment. All subsidy costs are better in both alternative modes in the higher cost sub-alternatives because patronage increase is greater than operating cost increase. The relative subsidy advantage of light rail over busway decreases to 43 percent in the marginal category.

CHAPTER IX

GOALS ACHIEVEMENT

INTRODUCTION

Given the large investment of resources required to implement and operate a transit system, it is important to assess the degree to which each of the alternatives reinforces and aids in the achievement of established goals on the national, regional, and local levels. It is important to understand that improved transportation is not an end in itself but rather only a means toward seeking a better quality of life for the region's inhabitants. Therefore, goal compatibility becomes an important criteria for distinguishing between alternatives in the system selection process. This Chapter reviews the applicable national, regional and local goals and discusses the relative performance of the transit alternatives under study as a means of helping attain these goals.

U.S. URBAN MASS TRANSPORTATION AGENCY (UMTA) GOALS

UMTA has set forth goals and objectives to be achieved through the implementation of mass transit and any transit system soliciting Federal financial assistance must be designed to support these goals. UMTA has established both long-term goals and near-term objectives to be served through implementation and operation of public transit.

The broad long-term goal of UMTA is to improve urban life and the urban environment by means of mass transit. Other goals include:

- Maximum spread (distribution) between all social costs and benefits

- Support of other national goals

- Achievement of goals of local area

To achieve its long-range goals, UMTA has also established near-term objectives. These include:

- Mobility of non-drivers (transit dependents)

- Relief of traffic congestion

- Improving the quality of the urban environment (air, noise, visual, etc)

Long-Range Goals

Improving the Urban Area

The overriding goal of UMTA is to improve the quality of urban life. As stated in the Urban Mass Transportation Act of 1964, as amended, "the welfare and vitality of urban areas, the satisfactory movement of people and goods within areas, and the effectiveness of housing, urban renewal, highway, and other federally aided programs are being jeopardized by the deterioration or inadequate provision of urban transportation facilities and services, the intensification of traffic congestion and the lack of coordinated transportation and other development planning on a comprehensive and continuing basis; Federal financial assistance for the development of efficient, coordinated mass transportation systems is essential to the solution of these urban problems."

The director of UMTA, Robert Patricelli, has indicated that rail transit can best achieve an improvement in the quality of urban life. In an article in Railway Age (April 12, 1976), he stated, "bus systems generally accommodate the largely uncontrolled patterns of city and suburban growth. Rail rapid transit development can be part of the planned development of cities and suburbs, and can help shape that growth. . . Rapid rail transit is part of becoming and being a great city." It should be noted, however, that improvement in the quality of urban life is accomplished through solving specific urban problems, control of urban growth being only one of many. As such, an assessment of how well each alternative achieves this broad, overall goal is dependent on the achievement of more specific national, regional, and local goals and objectives.

Maximum Spread Between All Social Costs and Benefits.

This is also a broad, encompassing goal; there are numerous social costs and social benefits of disparate natures accrued by any transit system, including economic, environmental, financial, technological, etc. There are numerous tangible and intangible factors which are relevant to the decision-making process and which need to be properly considered. Some of these factors are quantifiable and can be measured objectively while others can best be dealt with in qualitative terms and, by their nature, can be rated only subjectively. Further, it is recognized that different, and sometimes conflicting, viewpoints and value judgements are involved. Thus, "benefits" and "costs" can take on different meanings when viewed from the perspective of federal agencies, regional decision-makers charged with responsibility for funding or operating a proposed system, transit users riding the system, or non-users whose homes and businesses are impacted by proposed systems.

A basic purpose of this study was to help quantify the likely benefits and costs to be associated with each of the alternatives under study. To the extent possible, it also indicates how these benefits and costs might be distributed, both geographically and among special groups such as the lower income and other transit-dependents. It should be realized, however, that this project constitutes but one element of a larger, regional planning process which has the primary responsibility for maximizing the spread between all social costs and benefits.

Support of National Goals

A subset of UMTA's long range goals is the support of other national goals. Any federally assisted project should consider the larger perspective of national priorities and problems: Therefore, the transit alternatives are evaluated in light of other national goals. Those national goals which are impacted by transit development relate principally to the environment and to energy.

Environmental Goals. National environmental goals related to transit development are primarily established by the National Environmental Policy Act of 1969 and the Clean Air Amendments of 1970.

The National Environmental Policy Act (NEPA) establishes that it is the "policy of the Federal Government, in cooperation with State and local governments, and other concerned public and private organizations to use all practicable means and measures, including financial and technical assistance, in a manner calculated to foster and promote the general welfare, to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic and other requirements of present and future generations of Americans." To this end, it requires that all Federally funded projects assess the impact the project will have on the environment.

The Clean Air Amendments of 1970 requires the Environmental Protection Agency (EPA) to establish national air quality standards. It also provides the means for State establishment of emission standards.

This study has included a preliminary assessment of environmental impacts; a more detailed environmental impact report would be required for the selected system. Environmental issues related to distinguishing between alternatives are discussed in Chapter VII of this report. In terms of achievement of environmental goals, analysis identified important opportunities for land use, socio-economic and environmental benefit from the alternative transit modes and corridors in Santa Clara County. Further, none of the alternatives would present any insurmountable land use, socio-economic or natural environmental constraints which would automatically preclude it from further consideration, although there are sensitive locations in each corridor that provide a challenge to transit system designers to enhance environmental improvements and to avoid undesirable side effects.

- General Plan Compatability and Land Use Development Goals

  An overall assessment was made as part of this study of the compatability of the general plan for each city of the County with the transit alternatives under consideration. This material was presented in Working Paper 4 and the results are summarized subsequently in this chapter under the section dealing with local goals. In general, it was found that alternative modes are not equally compatible and that the Expanded Local Bus and Preferential Bus Treatment (TSM) alternatives appear most compatible with present general plans. It should be noted, however, that the regional planning agencies - the Metropolitan Transportation Commission (MTC) and the Association of Bay Area Governments (ABAG) are undertaking, in cooperation with local city and county agencies, a land use-transportation planning study for the Santa Clara County

area which is expected to provide considerably more insight into how transit and other transportation facilities relate to land use and urban development objectives and plans for the region.

- Protect and Enhance the Natural Environment

Light rail systems generally produce less air pollution than bus systems. This is particularly true since pollution from electric vehicles is concentrated around thermal power plants. For both systems the amount of emissions is relatively small in comparison with that from other sources. The system which diverts more auto drivers from their cars will, therefore, be the most attrative in terms of reducing air pollution and on these grounds the light rail alternative is to be preferred. Comparison of noise levels is always difficult because it is dependent upon the condition of the vehicles to be used, mode of operation and local site conditions. Buses can have low noise levels when cruising but they are noisy when accelerating. Without significant advances in technology the bus system would have a negative impact in the downtown areas and in the vicinity of suburban stations. Noise while cruising along the line would probably be about the same as that generated by a rail vehicle.

Rail systems generate the highest noise levels when cruising (specifications presently call for 75 dba at 15 feet and 40 mph). The system would be reasonably quiet wherever speeds were low so the major impact would be along the line itself rather than in downtown areas or near stations. Both transit systems operate at-grade and can be incorporated into the pedestrian network effectively. It is likely that quiet electric vehicles would be viewed as somewhat less intrusive than diesel buses in a pedestrian environment.

Both light rail and busway noise levels will be lower than arterial street or railroad noise levels. Short concrete barriers or earth berms can reduce noise levels to meet stringent EPA and local standards for residences 50 feet from the transitway.

The light rail system will require an overhead power source. Because of the location of the line, the catenary and supporting structures may be visually intrusive in some areas, notably the downtown, the Civic Center, IBM, and so on and special design provisions will have to be made to ameliorate this impact.

- Impacts on Socio-Economic Groups

In 1973 seven percent of the dwellings in Santa Clara County had no automobile available while 40 percent had only one. Thus there is clearly a sizeable portion of the population which depends on transit for their mobility.

Both the busway and the light rail line could be designed to serve the transportation disadvantaged. The rail vehicles are preferred in this case because of the possibility of level loading platforms and the wide doorways allow easier use by the aged and handicapped.

The impact on various groups in society depends upon the location of activities which are of interest to them. Both the light rail and the bus systems are centrally oriented to downtown San Jose with relatively few stops in the older parts of the city. As a result, they primarily serve trips from high and middle income suburbs to employment in the corridor and in the downtown. Lower income workers often live in the inner areas and have jobs farther out. Conventional transit systems may, therefore, do little to improve mobility for inner-city residents or for low income workers. There will be increased access from some of these areas to those jobs within

the corridor such as General Electric and IBM; however, relatively few jobs will be accessible from any one corridor.

Characteristically, higher ridership rates attest to the ability of rail transit and expanded local bus to serve a greater variety of trip purposes and population groups.

For these reasons light rail transit and expanded local bus probably provides greater mobility for non-downtown oriented trips.

Energy Goals. Over recent years, energy has become increasingly scarce and also has become an increasingly politically volatile issue. As a result, the United States has established the ambitious goal for itself of achievement of energy independence by 1985. To meet this goal, it will be necessary for the United States to develop new sources of energy, but also to reduce energy usage. With transportation accounting for 30.5 percent of the energy consumption in the San Francisoco Bay Area and private auto use accounting for 84 percent of gasoline consumption, any transportation-related project must be examined for its impact on energy usage.

Various studies have been done on the relative energy efficiency between transit modes. In general, these studies show that energy consumption per passenger-mile depends upon the volumes carried. There have been several studies in this area but so far the results are inconclusive. It appears that at low volumes buses are most efficient. However, if relatively high average load factors can be achieved, rail systems are superior. When discussing energy consumption two points must be considered:

-The source of energy may be important. For example, oil

sources may become depleted while electric power sources (hydro, coal, or nuclear based) may not be constrained to the same extent. The flexibility allowed by diverse power sources may be important in the long range.

-Compared with total transportation consumption, neither buses nor rail systems consume a large amount of power. Therefore, the most energy efficient system would be the one which diverts more auto drivers from their cars.

What becomes relevant, then, is the relative reduction in daily automobile vehicle miles of travel attributable to the various transit alternatives. This is shown in the following table:

Table 46 - Reduction in Automobile VMT - By Transit Mode

Mode	Reduced VMT
Baseline Bus	---
Bus Preferential Treatment	112,000
Expanded Local Bus	180,000
Busway	191,000
Light Rail Transit	225,000

From this analysis, it is evident that light rail would bring about the greatest reduction in energy consumption by automobiles.

Support of Local Goals

UMTA recognizes that urban priorities and problems differ from locality to locality. Therefore, it has established as one of the long range goals of transit development that it assist in the achievement of goals of local areas. This criterion is considered important enough to warrant a separate section which will follow the discussion of UMTA's near-term objectives.

Near Term Objectives

UMTA's near term objectives are designed to direct investment toward successful achievement of long term goals.

Mobility of Non-drivers

This objective is directed at serving the transportation needs of the young, elderly, poor, handicapped, unemployed, and secondary workers. These transit dependents do not have reasonable access to alternative forms of transportation and therefore the availability of adequate public transportation service is vital to their economic and social needs. Mobility of transit dependents is discussed specifically in Chapter V.

In terms of coverage, all of the transitway alternatives would serve these groups comparably with greatest coverage given by the expanded local bus. However, accessibility and mobility will be enhanced by the faster speeds associated with the light rail and busway transit alternatives.

Relief of Traffic Congestion/Reduced Need for Additional Highway and Parking Facilities

The proposed systems would have two impacts on traffic in the corridors. The first is a beneficial impact. Since an attractive alternative to the use of the auto is provided, traffic congestion or the need for road construction will be reduced. As discussed earlier, rail transit normally attracts higher ridership and the impact on traffic will be correspondingly greater.

The second effect is the negative impact of the physical presence of the transit system. The most important aspect of this problem would be the manner in which the transit vehicles circulate through downtown San Jose and make their way to the SP train depot. One

solution would be to convert one or two key downtown streets into transit-pedestrian malls. This would require closure of the streets to automobiles and trucks (cross traffic would be allowed).

This solution would work equally well for either the bus preferential treatment, busway or light rail aternatives. The resulting capacity of the converted streets to handle transit passengers would be higher with rail vehicles. This is due to the smaller number of vehicles required, the higher acceleration available and the lower loading/unloading times.

The light rail station stops will reduce the flexibility of the transportation system in the downtown somewhat. While it is unlikely that the location of the optimum transit corridor will shift, buses are more capable of accommodating unusual situations, such as construction site encroachments, traffic accidents and street and utility repairs.

With either transitway alternative, there is expected to be a significant improvement in 1990 peak-hour travel speeds on the parallel highway network due to a 15-20 percent switch from autos to transit. See Chapter V, Table 24 - Impacts on Parallel Highway Volumes and Speeds. Small delays would be experienced by motorists on crosstreets pre-empted by the transit vehicles, but these are expected to average no more than 15-30 seconds. Transitway users who formally rode local buses would experience a significant savings in trip travel time expected to average about 14 minutes per trip on the light rail system and 10 minutes on the busway.

The potential for reduced highway construction is greater with the light rail alternative because of its greater speed and capacity potential. By simply adding a second car on to each light rail vehicle the light rail systems peak-hour capacity could be doubled

from 4-5,000 per hour to 8-10,000 per hour, without the need for any additional drivers, assuming the fare collection system was changed to an off-vehicle station collection or "honor fare" system. The busway system, with on-line stations and step-loading through single doors, would reach its capacity at about 5-8,000 persons per hour. Major freeway projects which might be avoided by construction of transitways include construction of the Route 85 West Valley Freeway, construction of the Route 87 - Guadalupe Freeway and widening of Highway 17, U.S. 101 - Bayshore Highway and Route 82 - Monterey Highway.

The low-capital cost bus alternatives are not expected to produce the same order-of-magnitude travel time savings, mainly due to the fact that they would rely on using existing highway lanes and would reduce their auto-carrying capacity, in contrast to the construction of transitways which would increase the corridor's total passenger-carrying capacity. The bus preferential treatment alternative while increasing bus speeds is expected to cause a corresponding decrease in auto speeds, resulting in no net improvement in total person travel time. The increased local bus alternative would reduce the transit wait time an average of three to five minutes per trip and would serve to reduce highway congestion somewhat; however local buses would still be subject to arterial street traffic congestion, resulting in travel time losses for those persons switching over to the bus from their autos.

Improving Quality of Urban Environment

Although this is a specified near term UMTA Objective, it overlaps with UMTA's long term goal, national environmental goals and local concerns. Hence, the relative success in achievement of this goal by the various alternatives has already been discussed.

REGIONAL AND LOCAL GOALS AND OBJECTIVES

Several regional and local bodies have established transportation-related goals which the selected transit system should follow and reinforce. The most prominent of these agencies are the Metropolitan Transportation Commission, Santa Clara County and the City of San Jose. The transportation-related goals of other Santa Clara County communities in which the designated study corridors lie, including Cupertino, Saratoga, Monte Sereno, Los Gatos and Campbell, were also examined and found to be similar to those for San Jose and the County Transit District. The goals of the City of San Jose have been selected as illustrative of city goals. Because regional, county and local goals are overlapping, they will be individually identified but jointly discussed. Mention should also be made of State of California goals, such as those embodied in the California Environmental Quality Act (CEQA) which generally coincide and reinforce national and local goals.

The regional transportation goals and objectives were first developed in 1973 by the Metropolitan Transportation Commission (MTC), which is the San Francisco Bay Area transportation planning agency. MTC has developed an on-going Regional Transportation Plan (RTP) which provides the framework for transportation development and decision making in the nine-county Bay Area. The overriding goal established by the RTP is to provide a balanced transportation service with an emphasis on "transit first."

Santa Clara County adopted a set of nine public transportation goals in 1972 which are contained in the County Transit District's General Transit Plan. In June 1973 the County's Transportation Commission further clarified the major role they foresaw for transit in the future of Santa Clara County by adopting a long-range goal of achieving 30 percent of all travel by public transit.

The new San Jose General Plan for 1975-1990 was adopted in April 1976 and is aimed at meeting the need for a comprehensive statement of public policy to guide the City's future physical development. An important part of the new plan is the Transportation Element and its related goals. The specific transportation goals discussed in the plan are related to the overall goal to "provide safe, effective, environmentally responsive systems for the movement of people and goods."

Relation to National Goals

One of the objectives of UMTA is to support local goals and objectives. At the same time, all three of the local bodies, while not explicitly stating the goal of achieving national goals and objectives, have several specific goals which overlap certain national goals. These goals, identified below, take on special significances since they are common to all levels of government.

Improving the Urban Environment

Regional: "Transportation development programs should reinforce. . . the preservation and the enhancement of the environment."

Regional: "Transportation systems should minimize community disruption."

County: "The transit system will enhance the environment."

City: "Conserve the physical environment including both man-made and natural resources and amenities."

City: "Promote a transportation system which enhances the social environment and fosters compatibility and balance with our community life style."

Energy Conservation

Regional: "Transportation programs should contribute to energy conservation."

City: "Strive for maximum efficient use of energy resources when considering alternative transportation facilities."

Cost Effectiveness

County: "The transit system will be economical."

Accessibility and Mobility of Transit Dependents

Regional: "Transportation systems. . .serving all social groups, with special attention to the needs of the disadvantaged."

County: "The transit system will serve all people. . .regardless of age and income."

City: "Provide personal mobility such that all residents can fully participate in and enjoy the benefits of community life."

Other Regional and Local Goals

Other goals specified at the regional and local levels which do not overlap stated national goals include the following:

Competition with the Private Auto

Regional: "Transportation programs should be designed to reduce dependence on the private automobile."

County: "Santa Clara County will provide a transit system capable of attracting a major share of all travel. A goal of 30 percent transit ridership per day, which would return streets and highways to the number of cars in operation in 1967, and also would encourage transit ridership by persons using a second family car."

City: "To develop a public transit system that provides mobility to all the City's residents and reduces automobile congestion; and to do so in stages that are within the capabilities of the community."

"The City shall support one or more public transit systems capable of accomodating at least 15 percent of peak travel period demand by 1990."

"The City shall cooperate with other transportation agencies to assure that all residents have adequate access to public transit as an alternative to the automobile."

Achievement of a 30 percent daily transit ridership level is considered by the County to be a desirable, long-range goal, given the current financial, institutional and behavioral constraints and the lack of any auto restraints. However, a start on an attractive transit system capable of being upgraded and expanded to ultimately reach this goal can be made now in such a way as to gradually shift the balance of transportation use towards public transit over the long run. This has been termed a "grow into guideway" approach. As shown in Chapter V, both the bus TSM and the transitway alternatives would be capable of attracting about 15 percent of a corridor's peak-period travel demand in 1990. Thus where these types of transit alternatives were implemented, San Jose's transit ridership goal could be attained. However, on a County-wide basis, implementation of transitway alternatives in only these five study corridors

would only result in a 5-6 percent peak-period modal split. Also the Bus TSM/Bus Preferential Treatment alternative would be performing at or near capacity at these ridership levels and would not be capable of providing the additional capacity necessary to achieve the long-range goal of much higher transit ridership. Clearly if both the County and the City of San Jose's long-range transit ridership goals are to be met, a staged development of an attractive, high-speed, high-capacity transitway system will be required. By its "fixed" nature, a transitway represents a long-range committment of the County to an attractive transit system which could provide the physical and psychological framework for gradually altering the people's dependence on the automobile over time.

Compatibility with Comprehensive Plans

Regional: "Transportation development programs should reinforce comprehensive planning designed to guide population growth and economic development, and the preservation and enhancement of the environment."

City: "Provide safe and efficient access to land uses in a manner that fosters City policy for the rate and intensity of urban development." and more specifically,

"Direct future development to proceed in an orderly manner to achieve a balance between land use and transportation systems."

"Promote local transportation facilities which will encourage development in those industrial reserves which will provide convenient employment for community residents."

"Provide transportation services which will enhance downtown development policies."

> "An efficient and attractive public transit system which meets the travel demand at major activity centers shall be encouraged; with central San Jose, the municipal airport, and the Civic Center being given priority attention."

Because of the strong interplay between a region's land use, population, and employment development, and it's transportation systems, the transit system should be designed so as to encourage and reinforce the region's stated land use and development goals. In general, transitways are more supportive of, and in turn supported by, higher-density clustered development concentrated in strong, multipurpose activity centers. Local bus systems are, in general, more compatible with and supportive of lower-density scattered development which is dispersed over a wide area.

San Jose's new General Plan contains both supportive and nonsupportive elements in regard to the implementation of transitways. The supportive elements are: (1) encouragement of a strong multipurpose downtown regional activity center connected by transit links and transit/ pedestrian malls to the Civic Center, airport, and surrounding residential areas; (2) an increase in employment opportunities south of I-280 in the General Electric Company area; (3) creation of a large new industrial park and employment center near IBM in Edenvale; (4) a call for a significant increase in the role played by public transit, suggesting a 1,400 bus system for the entire County capable of attracting 15 percent of all peak-period travel demand in 1990; and (5) uses which have a high employment density or are otherwise heavy trip generators should be located in proximity to points of access to existing or future mass transit systems.

Elements contained in the General Plan which would not support transitways include: (1) a commitment to see additional freeway constructed in or adjacent to the transitway study corridors; (2) a

commitment to maintaining the existing low density, sprawl type of residential development; (3) limiting higher density development greater than three stories in height to the downtown core area, the airport and civic center areas, along the Alameda, adjacent to the Valley Fair, Eastridge and Almaden Fashion Plaza shopping centers, and at the intersection of Winchester and Hamilton Avenues.

Elements of the comprehensive plans of other cities in Santa Clara County would be achieved in part through transitway development, particularly the common goal to check urban sprawl. However, other elements of the general plans would discourage any higher-density transitway-induced development and would be more supportive of a low capital-cost bus alternative. These include a general trend away from higher density residential developments and the lack of commitment to concentrated activity center focuses, with the exception of Vallco Park in Cupertino.

Regional Coordination

Regional: "Coordinated and efficient services should be provided by operators in the region."

County: "The transit system will relate to the Bay Region."

City: "The City shall cooperate with the Santa Clara County Transit District and with other transportation agencies to develop corridor transit service and to provide convenient transfers between public transit systems and other modes of travel."

"Privately-owned transit systems, including taxicabs, Greyhound Bus, Southern Pacific, and others shall be encouraged to interface with the public transit system."

Regional transit service that links Santa Clara County with the rest of the Bay Area is currently provided by Southern Pacific, Western Greyhound Bus, and the County Transit District's buses to BART-Fremont and San Mateo County transit system in Menlo Park. All of the transit alternatives analyzed in the course of this study were assumed to connect with these regional transit services. In addition, the bus TSM/Bus Preferential Treatment and transitway alternatives were assumed to provide riders free and convenient transfer connections to SP trains at the San Jose Depot. These alternatives would thus act as feeders to the regional trunk rapid transit system and therefore more effectively meet this regional coordination goal.

Multi-modal Transportation

Regional: "All modes of transportation should be planned and operated on a coordinated basis."

County: "The transit system will be multi-modal with specialized service."

City: "Investigate the possibility of exclusive transit facilities such as bus lanes, people movers, and fixed-guideways."

The elements of a multi-modal transportation system include regional rapid transit, express transit for intra-county, medium distance travel local transit for feeder and local services, and specialized transit services.

The transitway and bus TSM/bus preferential treatment alternatives best achieve this goal by providing for fare and transfer coordination with the SP commuter rail regional transit system, express intra-county services on either transitways or reserved bus lanes, a local-collector-distributer bus system and specialized services such as handicapped vans, commuter buses and pools, and dial-a-ride in the South County. To the extent that preferential bus treatment may degrade automobile speeds, the transitway alternatives would provide better coordination among all modes.

Safety

Regional: "Transportation systems should maximize public safety."

County: "The transit system will be safe."

City: "Maximize convenience and safety for users of all transportation modes."

All alternatives are tried and tested technologies with excellent safety records. Both the Base busway and light rail alternatives with their numerous grade crossings of local streets are subject to potential automobile and pedestrian conflicts. The "SP/PUC Requirements" and "Higher Cost" sub-alternatives would offer fewer potential grade crossing conflicts, and as such would achieve high degrees of safety.

Use of Existing Investment

Regional: "More efficient use of existing facilities should be explored before new construction is undertaken."

City: "Maximize the use of existing streets by using dedicated rights-of-way in preference to street widening."

By doing an alternatives analysis, this goal is addressed. Alternatives involving high capital costs are compared with a Transportation Systems Management (TSM) alternative (bus preferential treatment) which would incorporate more efficient use of existing facilities by providing ramp metering, preferential carpool and bus lanes, and signal pre-emption in order to determine which alternative is the most cost-effective.

Citizen Participation

Regional: "Citizen participation should be encouraged as an important part of the planning and implementation process."

City: "Promote a transportation system which enhances the social environment and fosters compatibility and balance with our community life style."

"Minimize the disruption of neighborhoods attributable to transportation facilities and operations."

The transportation planning process has provided for substantial citizen input. Throughout the current study monthly public meetings have been held by both the County Transportation Commission and the Transit District Board to discuss the study's progress and key findings with the consultant. Many citizens have attended these meetings which were also televised on a local television channel and reported in several local newspapers. In addition the Transportation Agency has issued a monthly newletter called "Light Rail Notes" which has been mailed out to all city halls, libraries,

and thousands of interested citizens. The Transit Board has scheduled a series of meetings to be held in various communities around the county to discuss the study's findings, answer questions, and receive citizen feedback so that a consensus can eventually be reached on the final outcome of the project.

Staged Development

County: "The transit system will be developed in phases."

City: "Integrate the staged development of transportation facilities with those of all city services."

"To develop a public transit system that provides mobility to all the City's residents and reduces auto congestion; and to do so in stages that are within the capabilities of the community."

Implicitly recognized in this goal is that a county-wide transit system which will attract a major share of all trips will require a substantial community investment which can be accomplished only through staged development. Implementation of transitways in one or all of the five specified corridors are a means of beginning this staged development toward the ridership goal. The lower cost alternatives do not provide the same commitment to an attractive transit system which could be gradually expanded into a more extensive system eventually capable of achieving the County's transit ridership goal.

CHAPTER X

FINANCIAL FEASIBILITY

Although preparation of a financial plan was not included in the scope of this study, some attention must be paid to financial feasibility since it can be a significant factor in system selection. Financial analysis provides a means of comparing system costs at various levels to determine viability from the perspective of being able to pay for a proposed improvement and can be used as a tool for long term financial planning after system selection has been made. Under current conditions of escalating costs and fiscal pressures at all levels of government, financial feasibility becomes an increasingly critical component of investment decision-making. Therefore, the costs of each alternative have been examined in relation to the financial constraints which have been provided by Santa Clara County Transit District. The purpose of this financial analysis is to distinguish between alternatives solely in terms of these given constraints as one element in the system selection process. The exact nature of these constraints has not been determined at this time but it would be necessary to do so as part of a detailed financial program for the selected system.

This chapter will first address the viability of each of the systems in financial terms by comparing the alternatives' capital and operating costs with the County-specified constraints in order to determine possible surplus or shortfall of funds. The remainder of the chapter will discuss the inputs to the financial analysis; in the second section the derivation of the financial costs is addressed; and in the third section the derivation of the financial constraints is explained including a description of potentially available funds.

FINANCIAL FEASIBILITY ANALYSIS

Capital Cost Funding

Table 47 depicts the relative financial viability of implementing each of the alternatives.

The shortfall of funds is derived by deducting the capital constraint of funds available from incremental capital costs. The constraints shown represent the County's projection of the funds available through Fiscal Year 1980, assuming approximately 80 percent Federal matching. Because light rail and busway implementation extend through 1981 and 1982, respectively, additional funds may be available during those years. The potential amount of such funds would have to be examined in a more detailed financial program of the selected system. For this analysis it was elected to use the County-specified constraints as given.

The analysis indicates that funds to be used for capital funding will be inadequate to meet the costs of any of the alternatives with the exception of the baseline bus and the preferential bus treatment. A deficit of $10.5 million will be experienced by implementation of the expanded local bus fleet. Deficits for busway alternatives range from $160.3 million to $315.0 million, with a $171.6 million deficit for the base case busway. For the light rail alternatives, deficits range from $198.0 million to $397.2 million with an additional $280.1 million required for the base case light rail alternative.

The magnitude of the shortfall of funds of all transitway alternatives is significant. Of the total capital costs of these alternatives, approximately two-thirds of the costs are not covered by the potentially available funds. However, in keeping with the County's assumption that 80 percent of the costs would be funded by UMTA, the transit district would need to supply 20 percent of the shortage. The additional local funds required under this assumption for each of the alternatives is also shown in Table 47.

Table 47
INCREMENTAL CAPITAL COST FINANCING NEEDS FOR SYSTEM IMPLEMENTATION
(In Millions of inflated dollars)

	Base Case					Sub-Alternatives					
						Lower Cost		SP/PUC Requirements		Higher Cost	
	Baseline Bus	Bus Pref.	Expanded Bus	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail
Total Capital Cost	39.9*	47.7	78.0	239.1	381.8	227.8	299.7	279.7	420.6	382.5	498.9
Capital Cost Constraint	39.9*	67.5	67.5	67.5	101.7	67.5	101.7	67.5	101.7	67.5	101.7
Possible Shortfall in Capital Costs	--	--	10.5	171.6	280.1	160.3	198.0	212.2	318.9	315.0	397.2
Additional Local Capital Required (assumes 80% Federal funding)	--	--	2.1	34.3	56.0	32.1	39.6	42.4	63.8	63.0	78.8

* According to District's current 5-year T.I.P. issued December 1975

There are two key issues that affect the capital funding analysis. These are the availability of UMTA funds and the effect of delays in implementation.

Availability of UMTA Funds

It is critical to note that UMTA Section 3 capital grant monies are allocated solely at UMTA's discretion. Although the County's financial constraint assumes 80 percent Federal funding of capital costs, this amount is in no way guaranteed. There is currently intense competition for Section 3 funds. Of the original $11.8 billion, less than $2 billion is left after deducting the multi-year commitments to Buffalo, Miami, Atlanta, Balitmore and Philadelphia, and the projected requirements for planning, R & D, and routine bus grants. The requests for funds currently before UMTA far exceeds this amount. It is therefore necessary for UMTA to exercise the utmost selectivity in approving grants. As a result, they have established a number of guidelines and policies from which the following material has been drawn.

- Supportive Local Land Use Plans and Policies. UMTA does not seek to encourage any particular developmental patterns or to impose a national land use policy. However, cities that are prepared to exploit the developmental impact that a fixed guideway system can provide, e.g., to densify selected corridors, create metropolitan growth centers, preserve the core city, or achieve other effects that strengthen the vitality of the metropolitan area and promote energy-efficient land use patterns, will get preference in UMTA funding.

  Cities that adopt positive policies aimed at the generation of high levels of transit ridership will receive preference in funding. These policies at local option may include:

1) Zoning changes, joint development and other land use and development actions that will permit high density commercial and residential development in the transit corridor, especially adjacent to transit stations. By the same token, efforts to maintain low densities in the transit corridor, to bar commercial and office development around transit stations, to down-zone along the rights-of-way, and other actions aimed at attenuating the developmental impact of the proposed transit project would be considered an indication of a lack of consistency between transit and land use policies and a lack of commitment to policies that would support a high level of ridership on the system.

2) A moratorium on further freeway construction, especially in the corridors to be served by the proposed transit system.

3) Appropriate Transportation System Management actions (e.g., downtown parking restrictions, peak period automobile tolls, reserved transit lanes) to reduce unnecessary automobile use and promote transit habit, especially in the corridors to be served by the transit project.

UMTA will also give preference to communities which have a governmental structure that can facilitate coordination of transit planning and local land use decisions; that has authority to manage the various elements of the local transportation system, including automobile traffic, public transit and taxis; that has a power to achieve and maintain a balanced transportation program; and that is in a position to exploit the urban preservation or developmental impact of a fixed guideway system.

- Value Capture. Value-capture mechanisms can be used to recapture for transit financing purposes a portion of the real estate value increase generated as a result of the transit investment. UMTA

believes that it is eminently reasonable that the cost of building and operating a transit system should be met in part out of the real estate value increases which the system itself generates around transit stations and along the corridor. As a matter of equity, those who benefit should help pay for the system. Therefore, UMTA requires consideration of recovering increases in land value around the transit stations by such means as, for example, a special property tax assessment district. The tax increment collected would be used to help defray the construction costs of the transit system.

- Labor Peace. To assure that labor peace would prevail throughout the construction period, UMTA requires evidence of an agreement with local contractors and construction unions for peaceful resolution without work stoppages, of any labor disputes which might arise during the construction period. This would also require breaking the construction project down into small enough contracts that smaller contractors, including local minority firms, will be able to respond with a bid. It also means staging the construction over a long enough period so that local contractors will be able to bid on and perform more than one contract, and so that the local construction labor forces will be able to meet the work force demands without sudden large expansions and contractions, leading to outside workers coming in to meet demands for a short duration and then getting laid off.

In response to the spirit of these key items which UMTA is promoting as favorable factors to be considered in reaching decisions to finance major mass transportation projects, Santa Clara County has taken these positive steps to date:

- Transportation Systems Management Plan. The County Transit District is now in the first stages of implementing a coordinated bus priority/Transportation Systems Management (TSM) plan involving expansion of the bus fleet to 516 buses, inauguration

of peak-hour express bus services, new bus benches, shelters and bus stop signs, ramp metering of the area's most congested freeways by Caltrans (U.S. 101, Highway 17 and I-280), an innovative ridership promotion and marketing campaign, monthly bus passes, discount fares for youth, seniors and the handicapped, wheelchair lifts on all new buses, and a staged program of bus priority projects. The priority treatment techniques now being implemented include the reservation of curb lanes on the County's expressways and major arterial streets for buses and carpools, the installation of systems affording bus preemption of traffic signals, and the installation of bus-only activated signals at congested and hazardous turning locations. The objective of all these techniques is to increase the effectiveness of the local arterial road system by encouraging higher occupancy uses of private automobile and transit buses. This subject is also addressed in greater detail elsewhere in this report.

- <u>Supportive Land Use Plans and Policies</u>. The Transit District Board realizes the need to implement community and county land use/development plans which would tend to reinforce transitway use. They also recognize that land use/development planning and zoning is primarily a local community issue and area of responsibility. Questions of how a city should grow, in what form it should be in, and what the zoning and density allowances should be are best decided by the local communities involved together with their city councils and planning commissions. Consequently the Transit Board asked the consultant to test the significance on transitway ridership in 1990 of two different land use scenarios apart from the Base Case. The results showed that transitway ridership could be affected significantly by changes in current community land use plans which would allow somewhat higher densities to be built around station areas. The Transit Board expects to explore these land use possibilities with the individual communities affected to see if

there is local support or opposition towards land use plans which would reinforce the case for and use of transitways instead of more highways. The Board has therefore scheduled a series of workshop meetings with the individual cities to discuss the study's results, answer questions and achieve a consensus on what the final outcome of the project should be. As part of this review process, cities will be asked for their comments on whether or not they would be willing to change their general plans to make them more supportive of transitways.

The recently adopted new San Jose General Plan, for instance, if brought to fruition would substantially amplify the case for transitways in the Guadalupe/Monterey Highway corridor and in the West Valley Transportation Corridor. It should also be noted that cooridnated land use/transportation planning in Santa Clara County is the subject of the ongoing Santa Clara Valley Corridor Study being undertaken by MTC, ABAG and local agency staffs.

- Tax-Increment or Value-Capture Financing Mechanisms. The County contracted with Appraisal Research Company to study the possibilities of tax-increment financing and its application to transit financing. It was found that some problems do exist; the two most notable areas being legal questions and attempts to project the dollar value of revenues expected from such proposals. However, it was determined that the concept does have potential in Santa Clara County, particularly in the creation of limited joint redevelopment and transit projects for areas within the immediate vicinity of transit stations.

  If the Transit District decides to pursue the implementation of a light rail or busway transit project, it will further explore the possibilities of financing part of the system from such value-capture financing mechanisms.

The City of San Jose is also giving serious thought to coordinating their plans for development and redevelopment of their central area (using an expanded core concept) with the implementation of a light rail system for both regional access and central area circulation. While the financial plan for their project is still not complete, it is quite possible that value-capture concepts will be utilized for at least some portion of the financing and it may prove possible to have a combined undertaking which will include light rail transit financing as well as urban development/redevelopment.

- Assurance of Labor Peace During Construction. Santa Clara County has established general guidelines which address the subject of labor peace during construction. The plan is in line with UMTA's suggestions on the subject and is based on dividing the construction into contracts small enough for a widespread bidding response rate. Transit construction would be staged so that the existing local labor force will be able to handle the increased work load.

  If the Transit District decides to proceed to construction of a light rail or busway project, it is anticipated that every effort will be made to try and secure an agreement between the local area contractors and construction trade unions. Since construction worker unemployment in the County has been extremely high -- over 20 percent during most of 1975 -- it is expected that agreement for such a project could be readily reached from all parties concerned.

It is critical to note that meeting these four favorable UMTA consideration factors in no way assures Federal assistance. This is exemplified by UMTA's recent rejection of Denver's application for a capital grant to build a light rail system. Even though Denver had positively addressed the issues of tax increment financing, land use shaping, city general plan compatibility, and a Transportation Systems Management program, UMTA asserted that the City's population

density and the increase in ridership that light rail would attract over and above an expanded bus system were not great enough to justify the higher costs of the light rail system in the foreseeable future. Furthermore, it is likely that all of the remaining $11.8 billion allocated for Section 3 in the National Mass Transportation Assistance Act of 1974 will be completely committed prior to November, 1976. This indicates that any grant for Santa Clara County would be predicated on a new Congressional allocation, of which there are no assurances although circumstances are not discouraging at this time.

The Effect of Delays In Implementation

The escalated capital costs used in the financial analysis are contingent on staging of construction and vehicle acqusition beginning in 1977 for all alternatives and ending in 1979 for preferential bus treatment and expanded local bus system, 1981 for busway alternatives, and 1982 for light rail alternatives. In terms of engineering constraints, this is a realistic schedule. However, the potential institutional and political constraints are such that this schedule may be optimistic. It is possible that either the start-up or the progress could be delayed considerably. This eventuality would produce a dual effect. First, if the project is delayed in any way, those funds which are preempted to the transit system will increase over time, thereby potentially increasing funds available for system implementation. SCA 15 monies, 1/2 cent sales tax, and Mills-Alquist-Deddah funds will accrue annually and the latter two will keep pace with the rate of inflation. However, at the same time, construction costs will be escalating. At an assumed rate of eight percent per year which would be two to three percent higher than the assumed overall rate of inflation, the cost escalation would outstrip any added funds accumulated during the delay. As a result, any delays in construction are most likely to decrease the already limited financial viability of system implementation.

Operating and Maintenance Cost Funding

Analysis of the operating and maintenance costs shown in Table 48 indicates that none of the systems will be fully funded during the five-year period of Fiscal Year 1981 through 1985 with the exception of the baseline bus alternative. The expanded local bus fleet will experience by far the largest operations deficit, $240.3 million from 1981 through 1985. Bus Preferential Treatment (TSM) shows a $71.2 million deficit. The busway alternatives' shortfalls range from $40.0 to $45.5 million between start-up in 1982 and 1985. The light rail system alternatives, while experiencing the largest capital shortfalls, show the smallest operating shortfalls, ranging from $14.6 to $18.0 million between start-up in 1983 through 1985. The reasons for this lower light rail shortfall are:

- One less year of operating costs than the busway alternatives;
- Lower annual operating costs;
- Higher level of available funds with SCA 15.

The results are derived by first determining operating subsidies which are equal to operating costs net of fares collected. Funds available for operations financing are then deducted from the total subsidy to determine the possible shortfall in operating funds. All costs, fares, and constraints shown are the five-year total from 1981 through 1985. However, since light rail and busway operations do not commence until 1983 and 1982 respectively, operating costs and fares are only shown for years of revenue service. Operations financing is contingent on the baseline bus system operation. To determine the amounts available for funding all other alternatives' operation, projected baseline bus costs were netted against total monies available.

The fares shown are the incremental fares earned by the transit system as a result of alternative implementation. The fares collected by each

Table 48
INCREMENTAL OPERATING COST FINANCING NEEDS FY 1981 - 1985
(In millions of inflated dollars)

	Base Case					Sub-Alternatives					
						Lower Cost		SP/PUC Requirements		Higher Cost	
	Baseline Bus	Bus Pref.	Expanded Bus	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail
Operating Costs	311.3	93.5	274.2	68.9	45.0	61.3	45.7	68.9	45.0	74.8	48.6
Fares	47.1	8.0	19.6	9.9	10.2	7.0	7.5	9.9	10.2	15.0	13.8
Subsidy Requirement	264.3	85.5	254.6	59.0	34.8	54.3	38.2	59.0	34.8	59.8	34.8
Subsidy Constraint	282.3	14.3	14.3	14.3	20.2	14.3	20.2	14.3	20.2	14.3	20.2
Possible Shortfall in Operating Funds FY 1981 through 1985	--	71.2	240.3	44.7	14.6	40.0	18.0	44.7	14.6	45.5	14.6

alternative estimated at $0.17 per trip in 1976 are actually an amount somewhat greater than what is shown and meet the County requirement that one-third of the operating costs of the transitway be covered through the fare box. However, the additional fares earned by the transitway are in part offset by a decrease in baseline bus ridership and fares so that the net increase in fare revenues is equal to that shown.

Operating costs place a tremendous demand on the transit authority. It is a problem not unique to Santa Clara County. Over the last few years, major transit operators throughout the country have been faced with operating costs rising at high rates. In the last two years alone, operating expenses have increased 50 percent for Muni, AC Transit and BART. At the same time, fare levels have increased at a far lower rate in response to public pressures and so as not to lose patronage. As a result, operators have experienced an ever increasing cost-revenue gap.

For Santa Clara County, increased operating costs have a double-barrel effect. Not only do they directly cause all of the alternatives to appear financially infeasible as a result of the operating cost shortfall, it limits the money available for capital costs, rendering the systems financially infeasible due to the capital funding shortfall. This is because Santa Clara County's primary local source of funds, the 1/2-cent sales tax, is used optionally for capital and operations funding, with priority given to supporting the existing bus system. Projected amounts to be available from this tax source through 1980 are $89.2 million; $64.4 million is required for operations and maintenance.

The Transit District Board recognized this funding difficulty prior to the March 1976 sales tax election, and while realizing that passage of the 1/2-cent sales tax measure would not permit the installation and continued operation of the full five-corridor system, the Board was informed that a ten to fifteen mile useful first segment could be constructed and operated within the projected funding constraints.

FINANCIAL FEASIBILITY INPUTS

The following sections of the Chapter present additional information concerning the derivation of the escalated capital and operating cost estimates, the given financial constraints and potential sources of additional funding.

System Costs

Both capital and operating costs were estimated in detail and were discussed in Working Paper No. 6 and earlier in Chapter IV of this report. Although engineering cost estimates have utilized constant dollars throughout in order to maintain comparative consistency, the cost projections which result in a need for funds at a future date should include realistic estimates of current dollars which will be needed. Although escalation rates are impossible to project with certainty, "best guess" assumptions must be made. Caltrans has estimated an eight percent per year escalation rate for construction and equipment costs and a seven percent per year escalation for operating and maintenance costs. These were determined to be reasonable and have been used in this analysis.

Capital Costs

To determine the total capital requirement in inflated dollars, it was necessary to stage the system construction to determine annual costs for each year. This was done for each system and is discussed in Working Paper No. 6. The total costs by year are shown in inflated dollars for each alternative in Table 49.

Operating Costs

Operating costs were developed for a service level capable of handling 1990 patronage and are assumed constant (in 1976 dollars) for all years of revenue service. Differences between years are caused by inflation.

Table 49
ESCALATED INCREMENTAL SYSTEM IMPLEMENTATION CAPITAL COSTS
(In millions of dollars)

	Base Case					Sub-Alternatives					
						Lower Cost		SP/PUC Requirements		Higher Cost	
	Baseline Bus	Bus Pref.	Expanded Bus	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail
1977		1.5	24.0	4.0	5.2	3.8	4.1	4.7	5.7	6.4	6.7
1978		25.2	26.0	17.9	16.3	17.7	15.1	16.2	15.4	17.7	16.2
1979		21.0	28.0	19.2	23.8	19.0	17.3	17.5	22.7	19.2	23.6
1980				95.2	111.9	90.0	88.4	116.0	125.5	163.1	151.0
1981				102.8	120.9	97.3	95.4	125.3	135.5	176.1	163.0
1982					103.7		79.4		115.8		138.4
Total	39.9*	47.7	78.0	239.1	381.8	227.8	299.7	279.7	420.6	382.5	498.9

* Estimated by Santa Clara County Transportation Agency

Because the operating and maintenance cost constraint was specified as a total figure for the five year period, Fiscal Year 1981 through Fiscal Year 1985, operating costs were calculated for those years during that time period when the alternative was in revenue service. The incremental operating costs by year are shown in Table 50.

DERIVATION OF FINANCIAL CONSTRAINTS

Five Year Programs

The constraints used in the financial analysis are derived from the Santa Clara County Transit District's Five Year Plans for Fiscal Year 1976 through Fiscal Year 1980 and for Fiscal Year 1981 through Fiscal Year 1985. The dollar amounts of the constraints are predicated on projected amounts of currently available funds after deducting the costs of operating the existing system as well as the costs of expanding the bus system to a 516-bus fleet and constructing support facilities. These are shown in Tables 51 and 52. Where different than light rail, the monies available for bus alternatives are shown in parentheses.

Available Sources of Funds

In view of the anticipated shortfalls in both capital and operating funds, a review of funds available for transit support is appropriate. These include the following:

- Fare Revenues
- Federal Sources
  - UMTA
    - Section 3
    - Section 5
- Local Sources
  - SB 325 Funds
  - Proposition 5 Monies
  - 1/2-cent Sales Tax

Table 50
ESCALATED INCREMENTAL ANNUAL OPERATING COSTS
In millions of dollars

	Base Case					Sub-Alternatives					
						Lower Cost		SP/PUC Requirements		Higher Cost	
	Baseline Bus	Bus Pref.	Expanded Bus	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail	Busway	Light Rail
1981	54.1	16.3	47.7								
1982	57.9	17.4	51.0	15.5		13.8		15.5		16.8	
1983	62.0	18.6	54.6	16.6	14.0	14.8	14.2	16.6	14.0	18.0	15.1
1984	66.3	19.9	58.4	17.8	15.0	15.8	15.2	17.8	15.0	19.3	16.2
1985	71.0	21.3	62.5	19.0	16.0	16.9	16.3	19.0	16.0	20.7	17.3
Total	311.3	93.5	274.2	68.9	45.0	61.3	45.7	68.9	45.0	74.8	48.6

Table 51
PROPOSED FIRST FIVE-YEAR TRANSIT PROGRAM EXPENDITURES FY 1976 - 1980
(Expressed in millions of inflated dollars)

	Federal Capital Grants (UMTA Sect. 3)	Federal Operational Grants (UMTA Sect. 5)	1/2 Cent Sales Tax	Mills-Alquist-Deddeh	SCA-15	Total*
Existing Obligations (236 Fleet)	4.3	29.8	14.1	56.3		104.5
Bus Fleet Expansion (516 Fleet)	17.0		54.9			71.9
Support Facilities	6.1		7.2	5.3		18.6
Rail Alternatives (Bus Alternatives)**	78.6 (54.0)		13.0	0.5	9.6 (0)	101.7 (67.5)
Total	106.0 (81.4)	29.8	89.2	62.1	9.6 (0)	296.7 (262.5)

* All totals net of fares

** Where amounts available for bus alternatives differ from that for rail alternatives, bus amounts are shown in parenthesis.

Table 52
PROPOSED SECOND FIVE-YEAR TRANSIT PROGRAM EXPENDITURES FY 1981 - 1985
(Expressed in millions of inflated dollars)

	Federal Capital Grants (UMTA Sect. 3)	Federal Operational Grants (UMTA Sect. 5)	1/2 Cent Sales Tax	Mills-Alquist-Deddeh	SCA 15	Total*
Existing Obligations (516 Bus Fleet)		49.0	151.6	81.7		282.3
M & O - Light Rail Alternatives (Bus Alternatives)**			14.3		5.9 (-)	20.2 (14.3)
Reserve for Capital Expansion of Metro Rail					13.8 (-)	13.8 (-)
Sinking Fund for Phased Replacement of Bus Fleet			.4	.5		.9***
SUBTOTAL		49.0	166.3	82.2	19.7 (-)	317.2 (297.5)

Note: 3.0 million of 1/2 cent carried over from First Five-Year Program.
.5 million of MAD carried over from First Five-Year Program.

* All operating cost figures are net of fares

** Where amounts available for bus alternatives differ from that for rail alternatives, bus amounts are shown in parenthesis.

*** With 80 percent Federal funding, this would enable replacement of approximately 30 buses.

Fare Revenues

An important source of revenue is the fares generated by transit system operation. Since all outside sources of revenues are applied to the costs of the system net of fares, it is necessary to consider the fare revenues at the outset before applying additional Federal and local funds to the costs.

The level of fare revenue is directly related to fare rates and to patronage. The current fare level is 25 cents; with elderly, handicapped and student discounts, the average fare collected is equal to $0.17. This fare is assumed for baseline bus, preferential bus, expanded local bus, all collector-distributor systems and intra-County SP service. Fare levels for the transitway operation were established in light of the County mandate that 30 percent of the operating costs be recovered through the fare box. After modeling patronage and calculating operating costs, it was determined that a 25-cent base fare with an average fare of $0.17 would be sufficient to cover 30 percent of the costs of operating the transitway. Therefore, for all systems, annual fare revenues in 1976 dollars will be equal to the product of $0.17 and annual patronage. It has been assumed that fares will increase at an annual rate of 7 percent which is equal to the rate of increase assumed for operating costs. This is necessary to avoid a worsening cost-revenue gap but it is recognized that continuing fare increases may not be any more palatable to the public or politically acceptable in Santa Clara County than in other parts of the country.

UMTA

The current UMTA funding of mass transit was set forth in the National Mass Transportation Assistance Act of 1974 and, as stated earlier, the

Act allocates $11.8 billion between Fiscal Year 1975 and 1980 under two programs -- Discretionary Capital Grants (Section 3) and Formula Grant Program (Section 5). Each section has its own unique mechanism and constraints.

Section 3. The Capital Grant Program makes funds available for transit capital projects. A national total of $7.825 billion has been designated for this program during the six-year period of Fiscal Year 1975 to 1980. These monies are available for 80 percent funding of the net capital costs (defined as those costs which cannot reasonably be financed through revenues) but a commitment of local funds for the remaining 20 percent of the project costs is required. Monies are available on a grant application basis; no regional designations are specified. As stated earlier, competition for these funds is intense and it is probable that all present allocations will be committed by November 1976.

Section 5. The second source of UMTA funds is the Section 5 Formula Grant Program which was established by the National Mass Transportation Assistance Act of 1974. Section 5 allocates $3.975 billion nationally on the basis of population and population density. Between Fiscal Year 1975 and Fiscal Year 1980, the San Jose urbanized area was allocated $32.2 million. Funds may be used for either capital projects with an 80 percent Federal, 20 percent local match or for operating projects with a 50 percent Federal, 50 percent local match.

There are several constraints with the use of Section 5 funds, particularly when applying for operating grants. First, the Federal grant cannot be in substitution of the average amount of local subsidy of the two previous years; Federal funds can be used only as a supplement to these funds. Therefore, the Section 5 funds cannot be used to reduce the previous local share. Secondly, when using Federal funds, fares must be reduced to half the normal rate during off-peak hours for elderly and handicapped individuals.

The current allocation of Section 5 funds extends only through Fiscal Year 1980. It is reasonable to assume that the allocation will be extended. Santa Clara County has projected that it will receive $49.0 million between Fiscal Year 1981 and Fiscal Year 1985. However, operation of the committed bus fleet will require the use of all of this money; none will be available for the implementation of any added transit alternatives.

State/Local Fundings Sources

Mills-Alquist-Deddeh Act. The Transportation Development Act of 1971 (SB 325), known as the Mills-Alquist-Deddeh Act significantly extended the State sales tax by broadening the base to include gasoline. With the enlarged revenues, an equivalent of 1/4 percent of the total taxable sales is deposited in Local Transportation Funds (LTF) for transit-related purposes for each county on the basis of that county's regional sales.

A maximum of 85 percent of the LTF monies may be used for operating costs; for transit companies over five years old, SB 325 funds may cover only 50 percent of the operating costs not funded by Federal sources. This indicates that fare revenues plus other local revenues must cover 50 percent of the non-Federal costs. Fifteen percent of the SB 325 funds are to be used for capital projects.

Santa Clara County estimates that they will receive $62.1 million between Fiscal Year 1975 and 1980 of which $0.5 million will be available for transitway development. The remainder is to be used for operations of the existing system and for support facilities. In the period Fiscal Year 1981 to Fiscal Year 1985, the County projects that it will receive $82.2 million, all of which is required for baseline bus support.

Proposition 5 (SCA-15). Senate Constitutional Amendment No. 15 appeared on the June 4, 1974, primary election ballot as Proposition No. 5 and was approved by a majority of the State's voters. This amended Article 26 to permit motor vehicle revenues to be used for "the research, planning, construction and improvement of exclusive mass transit guideways (and their related fixed facilities), including the mitigation of their environmental effects, the payment for property taken or damaged for such pruposes, the administrative costs necessarily incurred in the foregoing purposes, and the maintenance of the structures and the immediate right-of-way for the public mass transit guideways, but excluding the maintenance and operating costs for mass transit power systems and mass transit passenger facilities, vehicles, equipment and services." Rolling stock, therefore, cannot be funded with "Prop. 5" monies.

As the law is currently interpreted, only rail transit can be funded with SCA-15 monies. The amendment does not clearly specify this limitation, however, and if tested in court, it may be shown busways are also legally eligible for SCA-15 funding. For the purposes of this analysis, however, it is assumed that only rail projects can use SCA-15 monies.

A companion bill to SCA-15, SB 819 sets up the maximum percentage of the motor vehicle fees that each of the recipients can divert to transit use. Two schedules are given; one gives maximum percentages under normal circumstances, and the second is a schedule of accelerated maximum percentages allowed in order to maximize Federal participation. The two schedules are given below:

Year	Normal Maximum	Accelerated Maximum
FY 1975	5	15
1976	10	20
1977	15	25
1978	20	No Limit
1979	25	No Limit

Within the constraint of the maximum limitations, the individual cities and counties have discretion over the fuel tax funds allocated to them in deciding on the amount diverted to transit. Caltrans and the California Highway Commission set up the division of State Highway Account Funds between highway and transit.

Santa Clara County Transit District estimates that $9.6 million will be available for rail transit implementation between Fiscal Year 1975 and 1980 with an additional $5.9 million for operations and $13.8 million for capital expansion between Fiscal Year 1981 and 1985.

One-Half Cent Sales Tax. In March 1976 the voters of Santa Clara County approved the passage of an additional 1/2-cent sales tax to be used solely for transit purposes. Within the constraint that the money collected be spent on transit, specific use of the tax is at the discretion of the Transit District. Of the $89.2 million estimated collections through 1980, $14.1 million is to be spent on the existing bus fleet, $54.9 million on bus fleet expansion, $7.2 million on support facilities, and $13.0 million on alternative implementation. Between Fiscal Year 1981 and 1985, $166.3 million is projected to be available. Of the total, $151.6 million is required for the committed bus system, $0.4 million will be placed in a sinking fund for bus replacement, leaving a balance of $14.3 million to be spent on maintenance and operation of the alternative selected.

CHAPTER XI

TECHNOLOGICAL SUITABILITY

INTRODUCTION

Technological suitability can sometimes be an important factor in the analysis of alternative transit systems. Although the use of mature technologies as a basis for selecting alternatives for analysis in this study reduces the criticality of this factor in the decision-making process, technological efficiency can still help discriminate among suitable modes. Various measures were evaluated during the study to determine the degrees of technological suitability of the alternatives being considered.

SAFETY

The levels of passenger safety on each alternative were evaluated in relative terms to reported safety performance on conventional bus and light rail systems.

The potential of patron exposure to accidents at stations and on board the vehicle are generally comparable among the alternatives. The elevated light rail transit alternative would be safest due to its predominately grade-separated operation.

At-grade light rail and bus alternatives both have somewhat lower safety characteristics than elevated light rail. Light rail safety is decreased in areas of operation where it operates at grade with potential highway interference and possible pedestrian penetration of the rail right-of-way. Bus alternatives range from safety levels comparable to existing experience for the null alternative to safety characteristics comparable to at-grade light rail operation where buses would operate in exclusive busways.

Passenger security in the station area is similar for all alternatives since unmanned passenger loading platforms have been planned. On-board security is comparable for bus and light rail alternatives since light rail is assumed to operate in single units with each vehicle manned.

TECHNICAL RISK

There is virtually no implementation risk associated with bus alternatives; the same is essentially true with light rail. Both represent mature technologies which have had many years of revenue service in the United States and abroad. Bus and light rail alternatives are state-of-the-art systems and present minimal risks if developed as specified in the system description.

FLEXIBILITY AND GROWTH POTENTIAL

Bus alternatives provide the most rapid opportunity to expand service into new areas or to shift routes as demand requires. Light rail expansion requires trackwork, and is dependent on the availability of funds. All of the alternatives have the potential for up-graded performance levels; however, the light rail alternative has the best possibility of improved performance resulting in significant travel time or cost savings.

Further, light rail alternatives have the most adaptability to accommodate increased patronage. The light rail alternative as presently conceived provides the ability to substantially increase standees on-board the system and if additional equipment is available, train length can be increased without the need for additional operational staff, allowing for more than double the forecasted 1990 peak-hour ridership. Bus alternatives have a limited ability to accommodate standees and require an additional operator for each additional vehicle placed in service. However, bus alternatives would be most adaptable to cutbacks in service during periods of lower travel demand.

PROCUREMENT RISK

There is inherent with each transit alternative a degree of risk concerning equipment availability and procurement lead time. Bus alternatives have the least risk associated with their procurement provided reasonably common bus specifications are used. Light rail alternatives involve potential time delays in vehicle delivery unless orders are placed with firms currently producing comparable vehicles. An order of significant size is necessary to entice potential producers to submit bids at acceptable cost levels, whereas buses can be procured in single units on an as-needed basis.

SERVICE DEPENDABILITY

The reliability of each alternative was assessed based on data provided by transit authorities operating comparable equipment and/or systems, equipment specifications and analyses of planned systems.

Analyses have indicated that bus and light rail alternatives, when operating on exclusive rights-of-way, could be made equally reliable from the standpoint of the number of trips completed on schedule, comparative mean-times-between-failures, and the time required to restore service. Light rail and bus both have the same potential for non-system interference resulting from external traffic impacts when operating in mixed traffic and at grade crossings.

CHAPTER XII

COMMUNITY ACCEPTABILITY AND POLITICAL SUPPORT

No alternative, regardless of its technical merits, should be selected unless it enjoys a significant level of community acceptance and political support. Public involvement in the light rail transit and alternatives analysis project is being accomplished by SCCTA staff. This is occuring via the Transportation Commission and Transit District Board monthly project review meetings and special briefings to be conducted by SCCTA staff upon request. The reaction of the public at these meetings must be given due consideration in the eventual selection of a preferred alternative.

During the conduct of this project, a number of special interest groups have voiced their support for a light rail transit system. These include the Loma Prieta Chapter of the Sierra Club, the Modern Transit Society and the Light Rail Coalition. A number of private citizens have also indicated their support for light rail at the Commission and Board review meetings and in their letters to the Board. Somewhat lesser public support has been shown for additional buses and busways. A few people have indicated an interest in electric trolley buses.

At a recent election in March 1976, Santa Clara County voters approved a 1/2-cent sales tax for transit development which was advertised as a three-part program to 1) continue support for the existing bus system; 2) expand the local bus system by 300 buses; and 3) study and fund the local share of a possible light rail starter system. The vote was 55/45 in favor of funding this transit program, while virtually all other tax financing proposals on the ballot went down to defeat. Just how many voters voted the way they did because of the possibility of a light rail starter line is not known. However, the activist groups noted earlier did campaign actively for the passage of this transit tax measure because of the inclusion of a light rail project and touted its merits.

Upon the presentation of this Final Report concluding the analysis and evaluation phases of this project, the Transit District has arranged for a series of community meetings in the various cities around the County for purposes of reviewing the study's findings, achieving understanding of the key results and reaching some consensus on what the final conclusions should be. Interested citizens and their city officials and planning staffs will thus have ample opportunities to become informed of the study results and let their desires and opinions be known.

Local political support for the preferred transit alternative would be indicated by approval of the Santa Clara County Board of Supervisors and by the elected officials of the municipalities affected by the proposed facilities.

The County's recommended transit plans must be reviewed and approved at the regional level in order to enjoy statewide support from the State-mandated 1/4-cent sales tax for transit (SB 325 funds), and must also be approved by the Federal government's appointed local clearing house for any Federal grant applications. The Metropolitan Transportation Commission (MTC) is the State of California's official reviewing body for transportation matters in the nine-county Bay Area which includes Santa Clara County. MTC is currently conducting two other transit studies which will have a direct bearing on the final outcome of this project. The first study, the Peninsula Transit Alternatives Project (PENTAP), is looking into the long-range possibilities of providing regional transit services in the SPRR/US 101 corridor from San Jose to San Francisco, and in the Highway 17/I-680 corridor from San Jose to BART-Fremont. The study is well underway and due to be completed by January 1977. The second study, conducted in conjunction with ABAG and the local city and county agencies, is concerned with the long-range, region-wide land use development and transportation alternatives for the Santa Clara Valley. This study is expected to include a regional transit "Alternatives Analysis" meeting the criteria of the Federal Urban Mass Transit Administration (UMTA). It appears at present that this regional level alternatives analysis must be successfully completed or at least substantially advanced prior to UMTA's review and approval of any major capital grant request for a fixed guideway system in Santa Clara County.

The County's recommended transit plans must also be reviewed and approved at the Federal level by officials of the Urban Mass Transit Administration in order to be eligible for and to receive Federal capital and operating assistance grants. Currently, UMTA has a very limited amount of money available for fixed guideway investments. It recently approved a capital grant of $269 million to build a 6.4-mile light rail starter line, mostly in subway, in Buffalo. UMTA also recently turned down Denver's request for $733 million to construct a 22-mile light rail starter line. The principal reasons given in turning down Denver's request are shown in the following quotation:

"1. For the foreseeable future, an improved bus system will provide equivalent transportation service and attract about the same number of riders as light rail, but at substantially less cost.

Your analyses examined both light rail transit and an expanded bus system in detail, and concluded that each would attract approximately the same ridership. In cost terms, however, your figures show that the bus alternative will be substantially less expensive. We believe that the capital cost of a reasonable expanded bus system would be less than one-third that of the light rail proposal, and that even when cumulative operating costs are added in, the bus proposal would still only cost about 60 percent as much as light rail by the year 2000.

We have examined carefully your concern that the volume of buses on the downtown streets in Denver would rapidly become too great to manage. We conclude from experience in several other cities that individual streets can handle between 100 and 200 buses per peak hour. By using various traffic management techniques designed to expedite the free flow of bus traffic, perhaps later combined with staggered work hours, we believe that you can accommodate likely levels of buses through at least 1995.

Finally, we note that while reduction of air pollution is a high priority in Denver, there is no significant difference between the bus and light rail alternatives in that regard.

2. The Denver light rail proposal does not compare favorably in cost-effectiveness terms with applications currently before us from other cities.

You know well that UMTA's capital assistance funds are sharply limited, and that we have before us a dollar volume of applications many times the amount we can fund. Thus, we must apply our funds to situations where the benefits of rail transit are most needed in the short to medium term. On this basis, Denver does not compare favorably. Yours is not an area of high population density (the Denver urbanized area ranks seventeenth in density among such areas), and your land development trends do not appear to be moving in a direction which would substantially change your absolute or relative density. Your problems of freeway congestion are not severe compared to those currently being experienced by many other communities. Finally, the capital cost per rider of your proposed light rail plan is one of the highest we are considering.

3. The long-term need for rail transit, and its potential community development benefits, are not sufficiently clear at this time to overcome the competitive disadvantage your light rail proposal faces compared to bus alternatives or the needs of other cities. Those broad but speculative community development benefits are sufficiently important, however, to justify Federal support to assist you in keeping the rail transit option open for the future.

The most difficult policy question faced by you and by us is whether, given the rapid growth of the Denver region, a light rail investment should be made now knowing that its real utility may not be fully justified for twenty years or more. From UMTA's point of view, given the funding pressures noted above, taking care of clear and present needs must take precedence over dealing with problems of future needs.

However, we are searching for ways we might assist communities like Denver, which might ultimately be able to justify rail transit as part of broader community development strategy, to keep the transit option open. We feel a strong obligation to manage the UMTA program in a way that supports locally initiated urban preservation and development programs.

We recognize that if a series of public and private commitments are made to manage growth patterns in the metropolitan area so as to support the development of suburban "activity centers," as your regional land use plan suggests, the justification for a transit investment would become stronger. In that regard, the relationship between rail transit development and community development patterns is likely to be an incremental one -- made up of mutually supportive small steps forward.

Therefore, we have concluded that a reasonable course of action would be to offer you loan funding to permit you to acquire and hold key real estate for possible subsequent transit development. Federal funding for light rail construction could be forthcoming some years in the future if the need for high volume transit becomes clearer and if the community has strengthened the case for light rail by making it part of a realistic community development and growth management program. Another question still to be addressed in the region is whether the role of the automobile should be restrained in any way if a massive transit investment is to be made.

Land acquisition at this time would also permit you to put in place certain of the value capture proposals which were recently presented to us in your May 1976 report. We congratulate you, Governor Lamm, and others who contributed to that important set of proposals."

It should be noted that much, if not all, of the data on which UMTA appears to have based its Denver decision is now or will be available at the end of this project. While perhaps a formal capital grant application might have to await significant progress on the County-wide land use/transportation

alternatives study being carried out by MTC, ABAG and local agencies, it is not too soon to seek a preliminary evaluation by UMTA to determine whether the necessary degree of political support at the national level can be realistically anticipated.

The SCCTA staff has been and will continue to be keeping all concerned officials and public representatives at the local, regional and national levels informed of the progress of this study so as to provide the maximum possibility of agreement on a preferred transit alternative at the conclusion of this project.

CHAPTER XIII

BASIS FOR DECISION-MAKING

In response to UMTA guidelines and in accordance with good transportation planning practice, this light rail feasibility study and alternatives analysis has considered a large number of transit alternatives. These have included corridor alternatives, different alignment alternatives within corridors, transit mode alternatives and design standard/service level options (sub-alternatives) for the busway and light rail systems. Further, in recognition that transportation system selection should consider both tangible and intangible factors for transit system users and non-users as well, a broad spectrum of evaluation measures were defined and evaluated. The results of these analyses were reported on in considerable detail in the seven working papers issued during the course of the study and have been summarized in other chapters of this final report.

The various local, regional and Federal decision-makers are now faced with a comprehensive but almost incomprehensible array of data which they must absorb, interpret and compare in accordance with their own individual experiences, sense of priorities and value judgments. The basic questions involved can be summarized as follows:

- Which of the alternative modes or combinations of modes should be selected for implementation in Santa Clara County on a system-wide basis?

- If either the busway or light rail mode alternative should be selected, what is the most appropriate design standard/service level option for near-term implementation (i.e., in the next five to ten years)?

- Assuming that not all of the five study corridors are equally attractive, what should be their relative priorities for implementation?

EVALUATION METHODOLOGY

A number of analytical approaches have been followed elsewhere in an attempt to facilitate transportation decision making, including such methods as: Planning Balance Sheet, Goals Achievement Matrix and Cost-Effectiveness Analysis. These are well-described in the professional literature.* Recently, Denver utilized a cost-effectiveness analysis after narrowing the choice to a domain within which quantitative analysis was deemed appropriate; Pittsburgh used a successive screening approach, while Los Angeles employed the Delphi technique to establish the relative importance of evaluation criteria. The alternative analysis for each of these three cities have generally been well received by UMTA personnel and local angecy staffs. De Leuw, Cather & Company led the alternatives analysis consultant effort in these cities and has combined elements of each of the three city's approaches into the work program for this study, modified as deemed most appropriate for conditions in Santa Clara County.

It is stressed that the following comparative evaluation is not meant to usurp the role of the local, regional or Federal decision-maker. Rather, <u>it is intended as an illustration of a process using the consultant's value judgments and sense of priorities.</u> It is hoped that each public official, staff members and citizens of the area can find the time needed to review at least the summary sections of the seven indivdual

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*See, for example, Transportation Research Board NCHRP Report No. 96, <u>Strategies for the Evaluation of Alternative Transportation Plans</u>, 1970; and NCHRP Report No. 146, <u>Alternative Multimodal Passenger Transportation Systems, Comparative Economic Analysis</u>, 1973.

working papers and the information contained in this final report, follow through the process shown below (or some other approach if preferred) and arrive at individual conclusions based on their own informed judgments and trade-off analyses using the factual data developed in the course of this study.

In discussing each of the seven evaluation areas shown below, the intention has been to select from the information developed during the course of this study those elements which appeared to the consultant to be both of major significance and which revealed differences among alternatives. That is, measures which were thought to be of secondary importance or which were judged to be essentially equal for all alternatives and thus did not help to discriminate among choices were generally not included in the discussions.

MODE ALTERNATIVES

Transportation Service Measures

These measures consist of: number of peak hour and daily transit passengers served, modal split, access to selected activity centers, "walk-in" population and employment, service to transit dependents, access by transit to employment opportunities, impact on freeway/expressway congestion levels and impact on parking space requirements.

Today's 236-bus fleet serves about 8,000 peak-hour and 40,000 daily riders. By 1990, it is estimated that the Baseline 516-Bus system would serve 15,000 peak-hour trips (3.8% modal split) and 120,000 daily trips (2.0%). The light rail and complementary collection-distribution-local bus system would attract the greatest number of riders -- 21,500 (5.5%) peak-hour and 160,000 (2.7%) daily -- of all the corridor system alternatives. The expanded local bus system, a virtual doubling of the bus fleet, would attract slightly more patronage but is not really directly comparable since this alternative is County-wide in concept rather than being limited to the five study corridors.

Accessibility/mobility measures for transit dependants as well as the general population would be best enhanced by faster speeds on exclusive guideway grade-separated transit facilities, assuming a good feeder-distribution bus complement. Buses operating in mixed traffic over local streets (i.e., baseline and expanded local bus concepts) will have somewhat lower accessibility/mobility measures. Large-scale transit facilities generally can provide better accommodation for the handicapped (e.g., level boarding platforms, elevators, wide doors).

A visual summary of the mode alternative evaluation measures can be seen in Table 53.

Economic Feasibility

These measures included estimates of: primary annual benefits, potential "add-on" benefits, total capital cost, annualized capital costs, annual operating costs, total incremental annual costs, benefit-cost ratios without and with potential "add-on" benefits, total system annualized capital and operating cost per passenger and per passenger-mile, incremental system cost per passenger and per passenger-mile, system subsidy requirements per passenger and per passenger-mile and incremental subsidy requirements per passenger and per passenger-mile.

The alternative producing the greatest primary annual benefit was the light rail system, which at $25.8 million (in 1976 dollars) even exceeded the results from the 1,000 bus expanded local bus system alternative ($24.4 million) which, as already stated, is not directly comparable since it applies to a much greater County-wide area. The estimated light rail potential "add-on" benefits of $10.4 million per year were also greater than for any other alternative mode.

In terms of combined incremental annualized capital and operating costs, the bus preferential treatment (TSM) mode appears best with a cost of $15.2 million vs. $24.0 million for the next best mode (busway) at an assumed discount rate of seven percent.

Table 53
SUMMARY OF MODE ALTERNATIVE EVALUATION MEASURES

Evaluation Measures	Baseline Bus	Expanded Local Bus	Bus Pref. Treatment	Busway	Light Rail
TRANSPORTATION SERVICE					
Patronage & Modal Split		▨			▨
Mobility/Accessibility		▨		▨	▨
Highway & Parking Impact				▨	▨
ECONOMIC FEASIBILITY					
Annual Benefits		▨			▨
Combined Capital & Oper. Costs			▨		
Benefit-Cost Ratio				▨	▨
Combined Cost/Passenger	▨				
Combined Cost/Passenger-Mile	▨		▨	▨	▨
ENVIRONMENTAL SENSITIVITY					
General Plan Compatibility	▨	▨			
Directing Urban Growth					▨
Socio-economic Impact		▨			
Natural Environment Impact	▨	▨			
FINANCIAL FEASIBILITY					
Capital Cost Constraint	▨		▨		
Operating Cost Constraint	▨				
Subsidy Required/Passenger	▨				▨
GOALS ACHIEVEMENT					
National				▨	▨
Regional				▨	▨
Local				▨	▨
TECHNOLOGICAL SUITABILITY					
Composite Performance					
COMMUNITY SUPPORT					
Public	▨				▨
Political Leaders	▨				▨

Legend: ▨ Preferred/Performs Best in Consultant's Judgment
(Lack of any box shaded indicates no clear choice.)

The highest benefit-cost ratio was found for the light rail and busway alternatives: 0.9 at a seven percent discount rate without considering potential add-on benefits, and 1.2 with the add-on benefits included.

With respect to transit efficiency measures such as combined capital and operating cost, the baseline bus does considerably better on a cost-per-passenger basis ($1.34 vs. $1.61 for the next best). Combined costs per passenger-mile are virtually the same for all alternatives except the expanded local bus, which is significantly more costly.

Environmental Sensitivity

These measures can be grouped into such basic areas as general plan compatibility, directing urban growth, socio-economic impacts and natural environment impacts. They are among the most difficult measures to summarize succinctly without oversimplifying. They also involve a fair amount of interpretive judgment as well as data analysis. For these reasons, a review of Chapter VII of this report and Working Paper No. 4 (with amending correspondence) is recommended for those with special interest in this topic.

The environmental analysis indicated that the baseline bus and expanded local bus alternatives were most compatible with the majority of existing city general plans, but that careful siting of a light rail alternative would not be unacceptable. After consideration of other land use aspects such as joint station/building opportunities, collateral development possibilities and station area land use impact potential, the light rail mode was judged to offer the greatest possibility for directing urban growth if favorable conditions can be encouraged and appropriate supporting actions taken.

Socio-economic considerations include mobility/accessibility, impacts on community services, need for relocation of residences and employers, economic pressure around stations, compatibility with neighborhood character

and equity to local governments. The net result was judged to be approximately the same for all the alternatives except for the expanded local bus which has the capability of serving widespread transit-dependent groups. There are, however, some significant internal differences which tended to cancel each other out when an overview of this area as a whole was made.

The natural environment impact evaluation considered such factors as air quality improvement, energy conservation, noise, visual intrusion, ecosystem impact, water resources impact, soils and geology, parks and open space and historic and archeological impacts. Again, each mode scored highly in one or more of these sub-areas, but on balance it was concluded that the baseline bus and the bus preferential treatment alternatives -- since they involve the least change to existing conditions -- were to be preferred from the standpoint of impact on the natural environment. It should be noted, however, as already stated elsewhere in this report, that no insurmountable environmental problems have been discovered in the work done to date for any of the alternatives or corridors investigated.

Financial Feasibility

The basic measures in this area of evaluation are the ability of each alternative to satisfy the anticipated constraints on capital and operating costs as estimated by the Santa Clara County Transportation Agency. It should be noted that the specified constraints are based on the assumption of 80 percent funding of system implementation costs by the Federal Government -- an assumption which may or may not be valid considering the limited amount of funds presently available and the strong competition among other regions for these monies.

The analysis indicates that the stipulated capital funds available ($101.7 million for light rail, $67.5 million for bus) will be inadequate to meet the implementation costs of any of the alternatives except the baseline bus and bus preferential treatment. Deficits range from $10.5 million (in inflated dollars)

for the expanded local bus fleet to $280.1 million for the light rail system in all five study corridors. The situation appears even worse in regard to operating and maintenance costs. It appears that only the baseline bus alternative can satisfy the given O & M cost constraint. The light rail system, because of its higher patronage (hence higher revenue) and lower operating costs, has the least shortfall of all the other transit alternatives. The annual subsidy required per light rail system passenger ($0.94) is slightly less than that of the baseline bus ($0.96) and considerably less than that required for all the other alternatives. As was stated earlier, the Transit District Board was fully appraised of this situation as early as December 1975 when the 1/2-cent transit program was presented and adopted. The transit program report pointed out that although funding would not be possible for the full 34 miles of corridors being investigated, sufficient funds were anticipated to construct and operate an initial 10 to 15 mile useful segment.

Goals Achievement

These measures are designed to indicate how well the various alternatives support national, regional and local goals. National goals include improvement of the quality of urban life, maximum spread (equity) between all social costs and benefits, support of other national goals (environmental protection, energy conservation), impacts on socio-economic groups, mobility of transit dependents, relief of traffic congestion and reduced need for additional automobile facilities.

Regional and local goals overlap national goals considerably. Additional goals include: the Metropolitan Transportation Commission's (MTC) overriding goal, as stated in the Regional Transportation Plan of providing a balanced transportation service with an emphasis on "transit first;" Santa Clara County's set of nine public transportation goals contained in the County transit District's General Transit Plan and the County Transportation Commission's adopted long-range goal of achieving 30 percent of all travel by public transit. These additional regional and local goals can be more explicitly stated as: reducing dependence on the private automobile; structuring new growth, economic development and

urban form in a more desirable manner in accordance with comprehensive plans; developing coordinated multi-modal regional transportation facilities; maximizing travel safety; maximizing use of existing facilities; providing for staged development of the transit system; and encouraging citizen participation in the planning process.

It is evident that all of the transit alternatives, if properly designed and implemented, can help achieve a variety of the national, regional and local goals. Some alternatives will perform better in certain areas than in others, and none is to be expressly preferred on all counts. It is difficult, therefore, to summarize this evaluation area, but on balance, it would appear that the two transitway alternatives are to be preferred to the baseline bus, expanded local bus and bus preferential treatment alternatives.

Technological Suitability

As already stated elsewhere in this report, use of proven bus and light rail technologies means that the measures of safety, technical risk, flexibility and growth potential, procurement risk and service dependability are virtually equal for all mode alternatives.

Community Acceptability and Political Support

The scheduled community meetings and public discussions leading to selection of a Final Action Plan by the Transportation Commission and approval by the Transit District Board will provide the best indication of how the alternatives and options compare in this evaluatiion area. Until such time, it appears that based on the results of the public meetings held to date, comments received from interested individuals and agencies, and the voter approval of the 1/2-cent sales tax in support of transit, baseline bus and light rail rank best from the viewpoint of local acceptability and political support. The degree of acceptability at the regional and national levels is uncertain and can only be resolved over time as responses are received to local requests for plan funding and implementation.

DESIGN STANDARD/SERVICE LEVEL OPTIONS

Both the busway and light rail alternative modes can be constructed with varying design standards which will result in better or worse service levels and higher or lower costs. This study generally followed standards consistent with good, modern European light rail design (Base Case) but also evaluated the consequences of conforming strictly to Southern Pacific Railroad and California Public Utilities Commission requirements (Meeting SP Requirements) and "Higher Cost" and "Lower Cost" options, as defined elsewhere in this report.

Transportation Service Measures

It is estimated that the "Base Case" and "Meeting Southern Pacific Requirements" options would have essentially the same number of at-grade crossings and consequently approximately the same patronage; if any difference exists it would tend to favor the "Meeting SP Requirements" option. The "Higher Cost" sub-alternative is anticiapted to average about 8 MPH faster than the "Base Case," and therefore would attract about 22 percent more peak-period riders (20,800 vs. 17,000). The "Lower Cost" option, on the other hand, would operate at an average speed approximately 5 MPH slower and would therefore attract about 15 percent fewer peak-period riders (14,500 vs. 17,000). These ridership changes would produce corresponding changes in mobility/accessibility and highway and parking impact measures.

A visual summary of the design standard/service level evaluation measures can be seen in Table 54.

Economic Feasibility

The total primary annual benefits increased as the options changes from the lower cost to the base case (which is equal in benefits produced by the Meeting SP Requirements option) to the higher cost sub-alternative.

Table 54
SUMMARY OF DESIGN STANDARD/SERVICE LEVEL EVALUATION MEASURES

Evaluation Measures	Base Case	Meeting SP/PUC Requirements	Higher Cost	Lower Cost
TRANSPORTATION SERVICE				
Patronage & Modal Split			//////	
Mobility/Accessibility			//////	
Highway & Parking Impact			//////	
ECONOMIC FEASIBILITY				
Annual Benefits			//////	
Combined Capital & Oper. Costs				//////
Benefit-Cost Ratio			//////	
Combined Cost/Passenger				
Combined Cost/Passenger-Mile				
ENVIRONMENTAL SENSITIVITY				
General Plan Compatibility				
Directing Urban Growth			//////	
Socio-economic Impact			//////	
Natural Environment Impact				//////
FINANCIAL FEASIBILITY				
Capital Cost Constraint				//////
Operating Cost Constraint				//////
Subsidy Required/Passenger				//////
GOALS ACHIEVEMENT				
National			//////	
Regional			//////	
Local			//////	
TECHNOLOGICAL SUITABILITY				
Composite Performance		//////	//////	
COMMUNITY SUPPORT				
Public	//////			
Political Leaders	//////			

Legend: ////////. Preferred/Performs Best in Consultant's Judgment
(Lack of any box shaded indicates no clear choice.)

These varied between $20.6 million in 1976 dollars to $32.6 million for light rail and between $16.3 million and $29.8 million for the busway. The potential add-on benefits followed similar patterns, ranging between $8.9 million and $11.7 million for the lower cost and higher cost light rail sub-alternatives.

Combined capital and operating costs are lowest for the lower cost option -- $22.3 million for the busway and $24.7 million for the light rail at a discount rate of seven percent. The benefit-cost ratio was found to be highest for the higher cost option -- 0.9 for the busway without add-on benefits and 1.3 if such benefits are included. The combined cost per passenger and per passenger-mile was virtually the same for all options.

Environmental Sensitivity

It was judged that all of the design standard/service level options would have approximately the same compatibility (or lack thereof) with existing general plans.

Considering the ability to direct urban growth, it is anticipated that results would be on the whole most favorable with the higher cost alternative. The same is also true for socio-economic considerations (particularly because of better accessibility/mobility resulting from higher speeds), but the lower cost option appears most favorable in minimizing impacts on the natural environment.

Financial Feasibility

In view of the estimated shortfalls in capital and operating funds, the lower cost alternative is preferred for both these measures. The lower cost alternative also produced the lowest subsidy required per passenger.

Goals Achievement

Since attainment of most of the stated national, regional and local goals would best be achieved by high-performance, high quality systems, it was concluded that the higher cost sub-alternative was preferred with respect to these measures.

Technological Suitability

It was concluded that such measures as safety, system reliability and so on would best be served by the meeting SP requirements and higher cost options.

Community Acceptability and Political Support

Strong feelings have been voiced from time to time throughout the study with respect to both the lower cost and higher cost options. Nevertheless, based on limited evidence available to date, it is the consultant's judgment that the base case option would generally be more acceptable than either of the extreme cases. This should be easily verified or rejected during the upcoming review period.

CORRIDOR COMPARISONS

A summary of the evaluation measures for the four basic designated study corridors is given in Table 55. It can be seen that study corridors 4, 4 Alternate and 5 -- which essentially traverse the same area of the County -- have been combined into a composite Guadalupe/Monterey Highway/ Lick Branch Corridor for comparative evaluation purposes.

It is also evident from the table that not all of the evaluation measures are particularly suited for choosing among the corridors designated for study. The two most useful measures, transportation service and environmental sensitivity, are, however, very important evaluation areas and constitute a valid basis for corridor selection.

Table 55
SUMMARY OF CORRIDOR EVALUATION MEASURES

Evaluation Measures	De Anza Branch WVTC	Vasona Branch	Blossom Hill WVTC	Guadalupe/ Monterey/Lick
TRANSPORTATION SERVICE				
Patronage & Modal Split				
Mobility/Accessibility				
Highway & Parking Impact				
ECONOMIC FEASIBILITY				
Annual Benefits				
Combined Capital & Oper. Cost:				
Benefit-Cost Ratio				
Combined Cost/Passenger				
Combined Cost/Passenger-Mile				
ENVIRONMENTAL SENSITIVITY				
General Plan Compatibility				
Directing Urban Growth				
Socio-economic Impact				
Natural Environment Impact				
FINANCIAL FEASIBILITY				
Capital Cost Constraint				
Operating Cost Constraint				
Subsidy Required/Passenger				
GOALS ACHIEVEMENT				
National				
Regional				
Local				
TECHNOLOGICAL SUITABILITY				
Composite Performance				
COMMUNITY SUPPORT				
Public				
Political Leaders				

Legend: ///////// Preferred/Performs Best in Consultant's Judgment
(Lack of any box shaded indicates no clear choice.)

Additional data is available in the form of the corridor capital cost sub-totals presented in Working Paper No. 6,"Capital and Operating Costs." It should also be noted that the following chapter of this report presents an analysis of a possible light rail starter line, including economic and financial considerations, of the corridor deemed most promising. That data can be compared with suitable portions of the bus system alternatives in this same corridor for those interested in making such a comparision (instead of the five corridor system-level comparision made in this chapter.)

Considering transportation service, it was found that the highest maximum load point peak-hour, peak-direction volume of about 4,500 riders occurs on the Guadalupe/Monterey Highway Corridor line, followed by 2,300 riders on the Vasona Corridor and approximately 1,000 riders maximum on each of the two branches making up the West Valley Transportation Corridor. The maximum improvement to auto travel speeds would occur in the Guadalupe/ Monterey Highway Corridor. Population concentrations of low income and elderly along the Vasona Branch and the Guadalupe/Monterey Highway corridors result in these being preferred from the standpoint of mobility/accessibility improvement.

No clear preference among the corridors was evident in terms of General Plan Compatability. Considering the opportunities to direct urban growth, the Vasona and Guadalupe/Monterey corridors appear best. Considering socio-economic factors, these same two corridors with their adjacent concentration of low income and elderly population also appear most desirable. There is no clear-cut preference among corridors when the net effect on the natural environment is considered.

No overriding differences, on the whole, were attributable to the individual corridors with respect to goals achievement or technological suitability. Most of the corridors, if not all, had vocal advocates and critics at various times during the study but the extent of such feelings is uncertain at present. The degree of public and political support for each corridor should become apparent during the course of the meetings taking place during the next several months.

TRADE-OFF COMPARISONS

The results of the evaluation measures assessment for the mode alternatives were summarized in Table 53. What still remains to be done is the making of trade-off comparisons both within individual major evaluation areas (transportation service, economic feasibility and so on) and among the seven major areas, leading to some final conclusions as the end results of this study and evaluation process.

At its simplest, the trade-off comparison process might merely consist of adding up the number of times each alternative was rated as Preferred/Performs Best -- as evidenced by the shaded boxes in the table. With such an approach, light rail with 13 boxes shaded would rank first, since baseline bus, the next highest alternative, has only 9 shaded boxes. Such a process would imply that each measure is of equal importance in decision-making.

One might also seek to first rank each of the evaluation measures in decreasing order of importance and sequentially evaluate only those alternatives which were judged satsifactory at the earlier levels. Or one might seek to assign a weight or indicator of relative importance to each measure and come up with a weighted point score reflecting both the number of times each alternative was rated Preferred/Performs Best and the relative importance of the categories in which it was so rated.

Rather than utilize any of the mechanical approaches just indicated, it is believed that this study should continue to explicitly feature the value judgments and priorities of individual decision-makers in conducting trade-off analysis. This can be done in a manner similar to that which was used initially to arrive at the Preferred/Performs Best designation. An example of this procedure follows.

Mode Alternatives

It can be seen from Table 53 that light rail is to be preferred from the viewpoint of transportation service measures, rating best in all three categories listed. At the same time, the expanded local bus and the busway alternatives are close behind, being rated as preferred in two of the three categories.

Considering economic feasibility, the light rail system was found to produce the highest annual economic benefits, followed closely by the expanded local bus alternative. Light rail (along with busway) had the highest benefit-cost ratio of all the alternatives (0.9 assuming a seven percent discount rate without potential "add-on" benefits but 1.2 if such benefits are included). Light rail was also among the alternatives to be preferred on the basis of combined annualized capital and operating costs per passenger-mile. The bus preferential treatment (TSM) alternative rated best, however, in the area of total combined annualized costs and the baseline bus system had the lowest combined costs per passenger. All in all, it was judged that light rail is to be preferred on economic feasibility grounds.

The expanded local bus system was rated best in three of the four environmental categories, followed by the baseline bus which scored well in two of the four. It is concluded that either of these two systems is to be preferred from the viewpoint of environmental sensitivity. It must be immediately pointed out, however, that light rail was the only alternative rated preferred/performs best in the important category of potential ability to help direct urban growth and no insurmountable problems with light rail were encountered in the course of the environmental analysis.

The very strong superiority of baseline bus is evident in the financial feasibility area. Indeed, it is the only alternative which satisfies both the given capital and operating cost constraints. The bus

preferential treatment (TSM) system meets the capital cost limitation requirement but not the operating cost constraint. Light rail was also rated preferred/performs best (along with baseline bus) with respect to lowest annual subsidy required per passenger.

Both transitway alternatives dominate the goals achievement evaluation area, while no clear mandate for any of the mode alternatives is evident in the assessment of technical suitability. Preference in the area of community acceptability and political support was rated as being evenly divided between the baseline bus and light rail systems.

Among the conclusions which can be drawn from the above re-capitulation of mode evaluation factors are:

- All of the mode alternatives have some positive features which recommend them in one or more evaluation areas.

- Light rail and baseline bus, being preferred in numerous categories, are the two most desirable alternatives.

- Only the baseline bus system satisfies the given capital and operating constraints. If light rail is to be considered further, therefore, it must be on a basis of less than full implementation in all study corridors.

Design Standard/Service Level Options

Table 54 indicates a very strong preference for the higher cost option since it was preferred in numerous major categories. On the other hand, the lower cost option was considered best in such key areas as low combined capital and operating cost and natural environment impact. Most importantly, given the inability of any alternative except baseline bus to meet the capital and operating cost constraints, the lower cost option is to be preferred from the standpoint of financial feasibility. These directly conflicting assessments suggest that a compromise on either the base case or the meeting SP requirements sub-alternatives would be in order.

Corridor Comparisons

It is evident that only a limited number of the evaluation measures shown in Table 55 are applicable to the issue of corridor priorities. Even for these, a clear preference was not always evident. It does appear, however, that on the basis of highest patronage and modal split, best impact on highway needs and from the veiwpoint of potential for helping to direct urban growth, the Guadalupe/Monterey Highway/Lick Branch corridor would be the preferred corridor.

CONCLUSIONS -- STARTER LINE RATIONALE

The fundamental conclusion arrived at on the basis of the evaluation process described in this chapter is that further consideration should be given to a light rail starter line in the Guadalupe/Monterey Highway/Lick Branch corridor, with design standards/service level corresponding to the base case or meeting SP requirements options. An analysis of a possible starter line can be found in the following chapter of this report and the rationale for its selection is summarized below (not necessarily in order of importance).

- All of the alternatives performed well in a number of areas. It is, therefore, not a question of "either-or" but rather of "how much" and "where" as the County seeks to implement a diverse, multi-modal transportation system that matches different modes and facilities in accordance with different travel needs and different urban characteristics.

- None of the alternatives studied except the baseline bus satisfied the given constraints on capital and operating costs. A logical starting point for an affordable initial system increment would be that corridor which offers the greatest possibility for attracting patronage under present planning projections, appears environmentally acceptable and has the potential for helping guide future urban development along desirable lines.

- The light rail system attracted the greatest patronage. It therefore produced the greatest improvement in operating conditions on parallel highway facilities and the greatest reduction in the need for additional parking spaces by 1990.

- A transitway provides a real alternative to investment in additional highway facilities in the Guadalupe/Monterey Highway corridor.

- The City of San Jose's new general plan calls for a transit system capable of attracting 15 percent of 1990 peak-hour travel; the light rail system achieved this capture rate in the corridors studied whereas bus and busway systems did not.

- The County Transit District's 30 percent transit ridership goal requires an attractive, high-performance, high-capacity system with an ultimate ability to accommodate volumes of up to 10,000 riders per hour during peak periods. Of all the alternatives studied, light rail comes closest to meeting these needs.

- The selected possible starter line supports the new San Jose General Plan goals and objectives by helping to encourage growth in the Central Business District (CBD), South San Jose and the Edenvale/IBM areas. It provides an opportunity for shaping and controlling urban development by establishing a high-quality transit axis that can directly link and serve four major activity centers: the CBD/convention center area, the Southern Pacific Railroad depot (proposed new transportation center), the Civic Center complex and the municipal airport. Coordinated urban development and transit planning and implementation will be necessary to take maximum advantage of this opportunity.

- The light rail alternative produced the highest benefit-cost ratio, between 0.9 and 1.2 depending upon whether or not potential "add-on" benefits are included. This ratio could be even greater depending upon how much increased patronage results from land use revisions

which might accompany implementation of the line if supporting actions are undertaken in conjunction with the detailed design and implementation of the rail line.

- The possible starter line is well suited to coordination with regional service since it would function both as a line haul facility for intra-County trips and as a collector-distributor facility for the regional transit system, be it the SP railroad or some form of new system to be implemented as a result of the ongoing MTC regional Peninsula Transit Alternatives Study.

- The light rail alternative requires the least annual subsidy per passenger. It has sufficient reserve capacity to accommodate continuing growth in patronage beyond 1990 without incurring directly corresponding increases in operating costs due to its ability to operate in multi-unit trains. This is not the case with any of the other alternatives studied.

- The light rail alternative, supported by a good collection-distribution-local bus service, provides considerable improvement in accessibility/mobility, particularly for such transit-dependent groups as low income households, the elderly and the handicapped.

- The West Valley Transportation Corridor (WVTC) right-of-way represents a unique resource which should be preserved for future public transit. Based on Denver's experience, it is possible that UMTA would consider loaning money for purchase of additional property needed in this corridor. Near-term uses could include designation as a hiking/walking trail and/or, with limited capital investment, as a bicycle path.

- Protection and preservation of the WVTC could also be the starting point for a coordinated program of urban development which seeks to enhance transit usage opportunities and provides a basis for extending the light rail system beyond the starter line segment at some future date.

- Advanced planning and design of the starter line can and should proceed in a coordinated manner with other transit improvements -- such as continuing expansion of local bus service and implementation of bus preferential treatment (TSM) facilities where these are found to be cost-effective. Implementation of the designated starter line can also be easily coordinated with planning for San Jose's Transportation Center and CBD circulation system.

In closing this chapter, it is well to recall again the quotation of the statement by Robert Patricelli, UMTA Administrator, which was cited earlier:

> ". . .bus systems generally accommodate the largely uncontrolled patterns of city and suburban growth. Rail rapid transit development can be part of the planned development of cities and suburbs, and can help shape that growth. . .Rapid rail transit is part of becoming and being a great city."

Santa Clara County is essentially facing the choice of a future similar to that which exists today in Los Angeles -- with all the advantages and disadvantages that this implies -- or one which provides the option for some its urban area -- by no means all -- to accommodate itself to transportation and urban development characteristics associated with one or more rail lines.

Technical studies such as this one can help to define the issues and quantify benefits, costs and the consequences of alternative actions. In the final analysis, however, the choice is dependent not on technical information alone, but on the unique and special way the County perceives itself and the future toward which it wishes to move.

CHAPTER XIV

POSSIBLE STARTER LINE

FUNDING CONSTRAINTS

Financial constraints at both the capital cost and operating cost levels limit the amount of transit improvements which can be implemented by the Santa Clara County Transit District in the next five to ten years. The District's current five-year Transportation Improvement Program (TIP) to 1980 shows that an estimated $101.7 million could be available for funding transit improvements assuming an 80 percent Federal matching grant. This assumes that at least $23.1 million will be made available from local funding sources. In addition, the succeeding five-year TIP to 1985 shows that an estimated $13.8 million in local monies would be available for transitway expansion. Assuming this money was also matched with an 80/20 Federal capital grant, another $69 million would be available for transitway construction between 1980 and 1985. Thus, as must as $170 million (in future year dollars) could be made available for transitway implementation and expansion between 1977 and 1985, the seven-to-eight-year time frame required for planning, design and construction of an initial light rail starter line.

It will be recalled that the costs for implementing the full, five-corridor light rail system were estimated to be $267 million in 1976 dollars for the "Base Case" design standards. If SP/PUC requirements were met, this cost would rise to an estimated $294 million. These two figures result in a range of between $8 and $9 million per mile for the full costs of light rail installation in Santa Clara County. At this rate, $101.7 million would buy about ten to twelve miles of light rail and $170 million, 18 to 21 miles, if the system could be constructed immediately in 1976. Such is not the case, however, and as was discussed earlier in Chapter IV, the earliest date at which construction of a light rail system for Santa Clara

County could be expected to commence, barring unforeseen delays, is January 1980. The mid-point of construction is estimated to be about June 1981 on this earliest possible time schedule, so that to the 1976 cost estimates should be added an amount to account for at least five years of inflation. Assuming an average rate of inflation in the construction industry of eight percent over the next five years, the 1976 costs should be multiplied by an escalation factor of 1.5. Thus, light rail implementation costs on a per mile basis should be considered in this light to be between $12 and $13.5 million. The five-year $101.7 million budget would buy about 7 to 8 miles of light rail, while the ten-year $170 million budget would buy about 12 to 14 miles. These fiscal constraints thus limit the size of the initial increment or starter system to a line about 9 to 14 miles in length and costing between $100 and $170 million.

A more stringent constraint appears to be the amount of money estimated to be available for the operation of any transit improvements in addition to the 516-bus fleet. The District's second five-year plan for the period 1981-1985 shows that an estimated $28.9 million, including fare revenues, are expected to be available for operating any additional transit improvements during that period. This amounts to about $3.5 million per year in 1976 dollars, taking into account inflation at eight percent per year. It will be recalled that the estimated annual costs to operate the full, five-corridor light rail system and purchase free transfer privileges for County transit riders from the Southern Pacific Company was estimated to be $8.75 million in 1976 dollars. Thus, under the present financial constraints, the Transit District could only operate about 40 percent of the 34-mile five-corridor system, or about 12 miles. Where the full five-corridor system required the operation of 40 light rail vehicles, the operation of only about 16 LRV's could be afforded under the current funding constraints.

SELECTION OF STARTER LINE CORRIDOR

Given these two funding constraints pointing to an 8-12 mile initial light rail segment costing no more than $113 million in 1976 dollars (equal to $170 million 1981 dollars) and requiring about $3.5 million 1976 dollars to operate, the next step was to locate where this initial increment should be constructed in order to maximize benefits and return on investment. In addition to funding considerations, it is generally desirable in accordance with good planning practice to incrementally implement a new system so as to be in a position to benefit from experience gained and to permit taking advantage of new developments and technological improvements as these become oeprational.

Benefits in transit investments are highly corelated with the transit ridership achieved, especially the number of new transit riders switching from private automobiles. From transit patronage levels achieved flow benefits such as auto operating costs saved, air pollutant reduction, energy savings, reduced levels of auto congestion, reduced accident levels on parallel highways, reduced demand for parking lot spaces at activity and employment centers, etc.

Looking at the partonage forecasts presented in Working Paper No. 5, the single line or corridor exhibiting the highest patronage potential is the one serving the Willow Glen, Almaden and Edenvale areas. The line showing the greatest ridership in 1990 is shown in Figure 58 and connects downtown San Jose and the SP train depot with General Electric and IBM, with a branch line from Lick Junction to Oakridge Mall and the Almaden Valley area. This corridor is shown to attract almost 4,000 riders per hour in 1990 if both the Edenvale/IBM and Almaden/Oakridge Mall branches were implemented. No other corridor studied in this project came close to this ridership level, the Vasona corridor ranking second with about 2300 peak-hour riders.

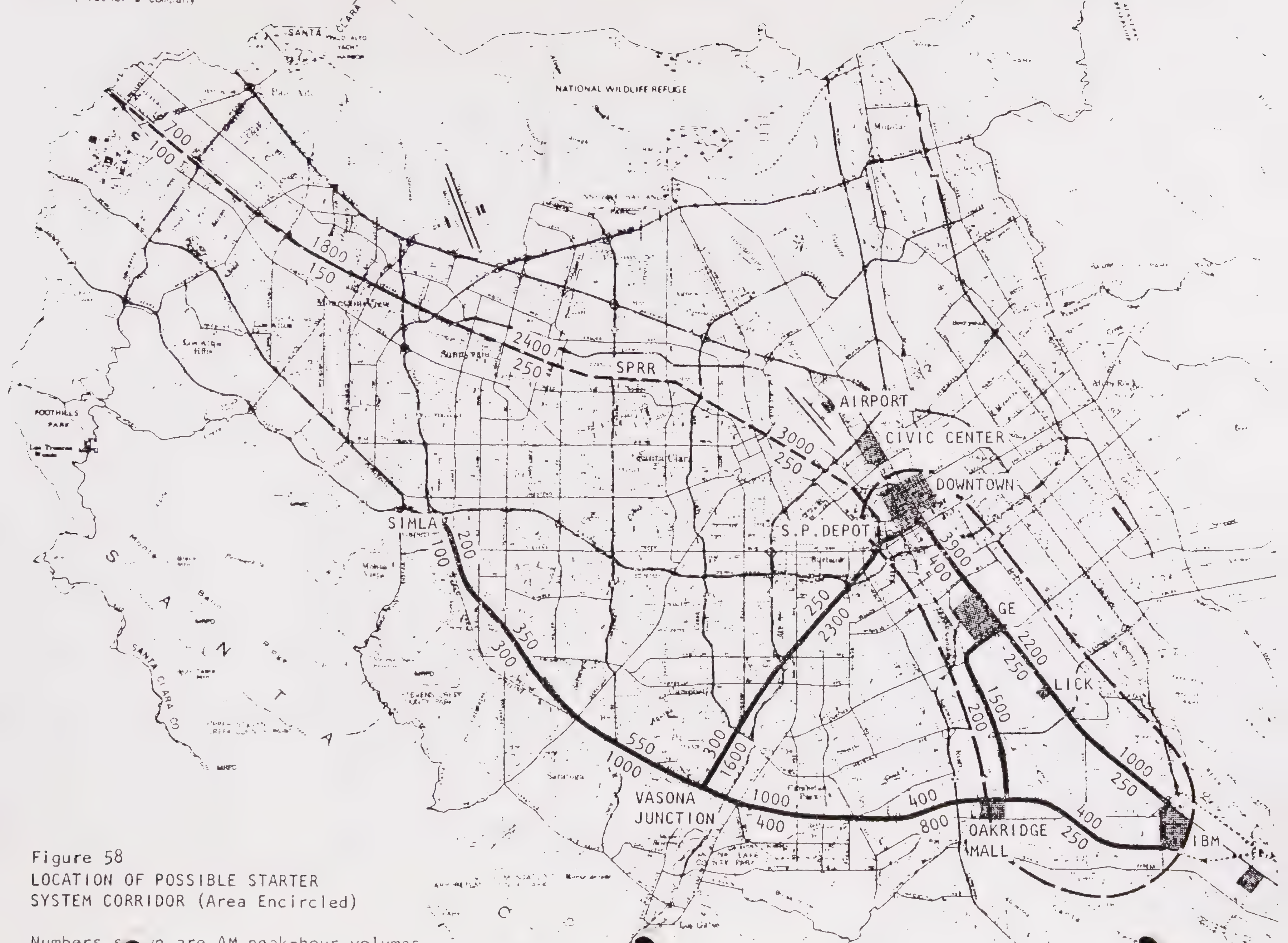

Figure 58
LOCATION OF POSSIBLE STARTER
SYSTEM CORRIDOR (Area Encircled)

Numbers s[illegible]n are AM peak-hour volumes

Without construction of the Guadalupe and West Valley freeways and without significant widening of US 101 between Highway 17 and IBM, severe highway congestion will be experienced on roads such as the Almaden Expressway and Monterey Highway after 1980, leading to pressures to curtail any additional development of the area or pressures to build additional highway lanes. Yet the new San Jose General Plan calls for a greatly increased focus of jobs in the CBD, in the areas of south San Jose north and south of General Electric at Curtner Avenue and Monterey Highway, and in the IBM industrial park area between Cottle Road and Bernal Road. The Plan also calls for the implementation of a transit system by 1990 which is capable of attracting at least 15 percent of the peak-hour travel demand then.

If a high-speed express transit facility were implemented to serve this travel corridor, it could be expected to capture between 15 and 20 percent of the peak-hour travel demand in the corridor, resulting in about 4,000 riders per hour past the maximum load point south of downtown San Jose in 1990 (see Figure 58) and about 30,000 transit riders daily over the system. Thus, the already heavily congested traffic arteries serving the Almaden and Edenvale areas, both of which are expected to grow substantially in residential development by 1990, would gain some much needed relief from an attractive parallel light rail line.

The San Jose General Plan further defines as a high priority transit link a system connecting the airport, civic center complex and downtown/convention center areas. In addition a recent proposal calling for a regional transportation center in a redevelopment area just north of downtown and adjacent to the Guadalupe Transportation Corridor has been advanced by Councilmember Jim Self. The proposed regional transportation hub would bring together in one common transfer point the Southern Pacific commuter railroad, AMTRAK, the proposed Canada-Mexico rail service, Greyhound, Continental Trailways, the County Transit District buses, any future BART extension south from Fremont and

an initial light rail starter or demonstration line. The proposed light rail demonstration line would loop around downtown San Jose on streets converted to pedestrian and transit malls, enter the Guadalupe Transportation Corridor (the right-of-way is 100 percent publicly owned now) and proceed north to the regional terminal site, the Civic Center and on to the municipal airport, a distance of about three miles. In addition, further extensions would be possibel beyond the airport to activity centers such as Marriott's "Great America" theme park with its two million annual visitors.

The regional transportation terminal and central area light rail circulation loop appear to offer considerable promise and are fully compatible with the possible light rail starter line in the Guadalupe Transportation Corridor just described. Without any apparent difficulties from an engineering sense it would be possible to extend the light rail starter line from its present terminus in this study at Park Avenue and the Guadalupe Transportation Corridor northward to a new regional transportation terminal, the Civic Center and municipal airport. Such an extension appears highly desirable from the viewpoint of passenger service (hence ability to attract additional patronage) as well as urban planning considerations -- i.e., connecting a series of major urban activity centers by high quality transit and thus creating an axis which can help give form and structure to future urban development.

For all of the above reasons, then, the Guadalupe/Monterey Highway/Lick Corridor was selected for evaluation as a possible initial light rail line which could eventually be expanded into other portions of the corridors under study, and even beyond if it were found to be desirable to do so. It should be noted that portions of other corridors, or combinations of corridors, might also have been selected for evaluation as potential light rail starter lines, including, for example, a De Anza Corridor-Vasona Branch Line linkage. Further, it would have been possible to consider for evaluation initial projects featuring mixes of modes combining, say, small segments of light rail with busways in some corridors and/or the purchase of the remaining right-of-way required in the West Valley and Guadalupe Transportation Corridors so as to preserve these areas for future transportation

services while seeking to bring about land use changes which would make these corridors more attractive from the viewpoint of transit ridership potential. In view of the time and budget limitations on this study, however, it was decided to evaluate only the Guadalupe/Monterey Highway/Lick Corridor as an illustrative light rail starter line with good potential for success. The selection of a starter line is, of course, a matter for the Transit District Board based on input from the Transportation Commission and other sources. The analysis shown in the subsequent sections of this chapter has been carried out to indicate how an evaluation might be made of a potential line which evidence to date indicates would attract the most patronage of all the corridors under study.

SELECTION OF A STARTER LINE ALIGNMENT

Figure 59 shows the chosen general alignment of the initial light rail corridor selected for evaluation. An alignment proceeding southward from a station terminus in downtown San Jose near the Park Plaza urban renewal area could be located in the median of the partially constructed Guadalupe Freeway. Almost the entire right-of-way has been purchased and cleared between Park Avenue and the Almaden Expressway by the State Department of Transportation, and some fill embankments already exist for major crossings such as I-280. South of Almaden Expressway, not much right-of-way has yet been purchased for the Guadalupe Freeway and the freeway alignment leads up to a large hill south of Curtner Avenue which would have to be cut through. An alternate alignment exists to the southeast along the SP mainline track between Almaden Expressway and Lick Junction which appears easier and cheaper to construct. The existing Almaden Expressway and Curtner Avenue overcrossings of the mainline railroad appear to have sufficient additional room for a transitway without much modification.

Upon reaching Lick Junction near the Monterey Highway just north of Capitol Expressway, the transitway could split into two separate branches. The first would proceed southeast to IBM in the strip of land which exists

Figure 59
POSSIBLE LIGHT RAIL STARTER
LINE ALIGNMENT

between the SP mainline and Monterey Highway. Alternately, the light rail tracks could be placed in the wide median strip which exists in the Monterey Highway, but this would present station access difficulties. This line would terminate at a station site near Cottle Road and the WVTC right-of-way after first stopping at a station located in the IBM complex. The second branch would proceed southwest from Lick Junction using the lightly used SP Lick Branch railroad right-of-way to a terminus near Oakridge Mall and Blossom Hill Road.

The total length of the common trunk line and Monterey Highway Branch is 8.5 miles, while the Lick Branch extension would add another 3.75 miles for a total starter system length of 12.25 miles.

ESTIMATED CAPITAL COSTS TO IMPLEMENT POTENTIAL STARTER LINE

The estimated costs to construct and implement the 12.25 mile starter line are shown in Table 56 in 1976 dollars. Table 57 shows how the starter line can be broken down into segments and the costs associated with each segment. Note that the light rail vehicles and their yards and maintenance facilities would account for almost 30 percent of the total costs of the starter line. Any subsequent additions to this initial increment would not require the heavy "start-up" costs incurred by the first segment.

The total cost of implementation including engineering design, construction supervision and a 25 percent contingency allowance is expected to be about $113 million in 1976 dollars. By 1981 this cost figure is expected to escalate by eight percent per year to approximately $169 million.

Table 56

NETWORK CAPITAL COST TOTALS

POSSIBLE LIGHT RAIL STARTER LINE "Meeting SP/PUC Requirements"	SECTION A Guadalupe Corridor From Park Ave. To Almaden Expressway 2.33 Miles	SECTION B SP Lick Corridor From Almaden Expressway To Lick Junction 1.80 Miles	SECTION C Monterey Corridor Lick Junction to Santa Teressa Station 4.33 Miles	SECTION D SP Lick Corridor Lick Junction to Blossom Hill Road 3.79 Miles	Network Subtotals	25% Contingency	Network Totals
	(June 1976 dollars)			(Cost in $ millions)			
Guideway	5.80	1.67	8.55	3.03	19.05	4.76	23.81
Trackwork	1.40	1.08	2.60	2.27	7.35	1.84	10.19
Electrification	1.63	1.26	3.03	2.65	8.57	2.14	10.71
Control	1.05	0.81	2.35	2.26	6.47	1.62	8.09
Landscaping	0.12	0.09	0.22	0.19	0.62	0.16	0.78
Noise Barriers	0.04	-	0.02	0.22	0.28	0.07	0.35
Stations	0.79	0.60	0.87	0.12	2.38	0.60	2.98
Parking lots	0.72	0.84	2.64	1.44	5.64	1.41	7.05
Street reconstruction	0.17	0.36	1.99	-	2.52	0.63	3.15
Relocation of RR tracks	0.18	-	-	-	0.18	0.05	0.23
Utility relocation	0.10	0.10	0.30	0.10	0.60	0.15	0.75
Right-of-way	1.37	0.50	1.19	1.31	4.37	1.09	5.46
Vehicles	25 x 600,000/vehicle =				15.00	3.75	18.75
Communication	25 x 5,000/vehicle =				0.13	0.03	0.16
Maintenance yard & shops					7.00	1.75	8.75
Right-of-way for maintenance yard					0.60	0.15	0.75
				Subtotals	80.76	20.19	100.95
				Agency cost 15%			12.11
				Network total			113.06

Table 57
POSSIBLE STARTER LINE CAPITAL COSTS

Segment	Length, Miles	Stations, Number	Estimated Costs (1976 dollars)
1. Guadalupe Freeway Corridor, Park Avenue to Almaden Expressway	2.33	4	$13.37
2. SP Mainline Railroad, Almaden Expressway to Lick Junction	1.80	2	7.31
3. Monterey Highway/SP Mainline, Lick Junction to IBM/WVTC	4.33	5	23.75
4. SP Lick Branch Line, Lick Junction to Oakridge Mall	3.79	4	13.60
SUBTOTALS	12.25	15	$58.03
Vehicles - 25 Articulated LRV's with Wheelchair Lifts & Radios			15.13
Maintenance Yard and Shops, including right-of-way			7.60
Engineering Design, Construction Supervision and Agency Costs (at 15 percent)			12.11
Contingency Allowance at 25 percent			20.19
TOTAL, 1976 Dollars			$113.06
TOTAL, 1981 Dollars			$169.50

ESTIMATED ANNUAL OPERATING COSTS FOR STARTER LINE

A modal split run for the approximately 12-mile starter line resulted in a forecast of 5,000 peak-hour and 30,000 daily riders in 1990. Figure 60 shows the peak-hour line loads expected on this starter line. The Monterey Highway/IBM branch would peak at about 2,000 riders per hour at Lick Junction while the Lick/Almaden branch would peak at about 1,000 riders there. Upon merging into a common trunk line and proceeding northward through south San Jose and Willow Glen, the line would pick up an additional 1,000 riders for a total of about 4,000 nearing the San Jose CBD. About half of these riders would disembark for destinations in downtown San Jose and the Civic Center while the remaining half would desire to continue their trip northward to Santa Clara, Sunnyvale, Mountain View and Palo Alto via a convenient and improved Southern Pacific passenger train service. The patronage forecast here assumed the same free SP transfer fare policy and 25-cent base fare that was assumed in the full system forecasts.

Figure 61 shows the basic operating strategy assumed for the starter line in 1990. The Monterey Highway/IBM branch would require 14 LRV's per hour to carry the peak-hour riders forecast, resulting in about four-minute headways. Thirteen LRV's would be required to service this 8.5-mile-long segment of the line assuming an average speed of 25 MPH, including all stops, layovers and turn-arounds. Similarly, the Lick/Almaden branch would require about nine LRV's per hour to handle the expected passenger loads, resulting in about seven-minute headways. Eight LRV's would be required to service this eight-mile long line assuming the same 25 MPH overall average speed. Thus a total active fleet of 21 LRV's would be required, and to this number should be added four spare vehicles for a total fleet requirement of 25 vehicles.

During the base period, the two branch line headways would be cut back to ten minutes, and during evening periods to 15 minutes. As a result of this operating policy, the annual vehicle-hours and vehicle-miles operated were calculated to be 61,000 and 1,500,000 respectively. These resulted in an annual operating cost estimate of $2.93 million in 1976 dollars, as shown in Table 58.

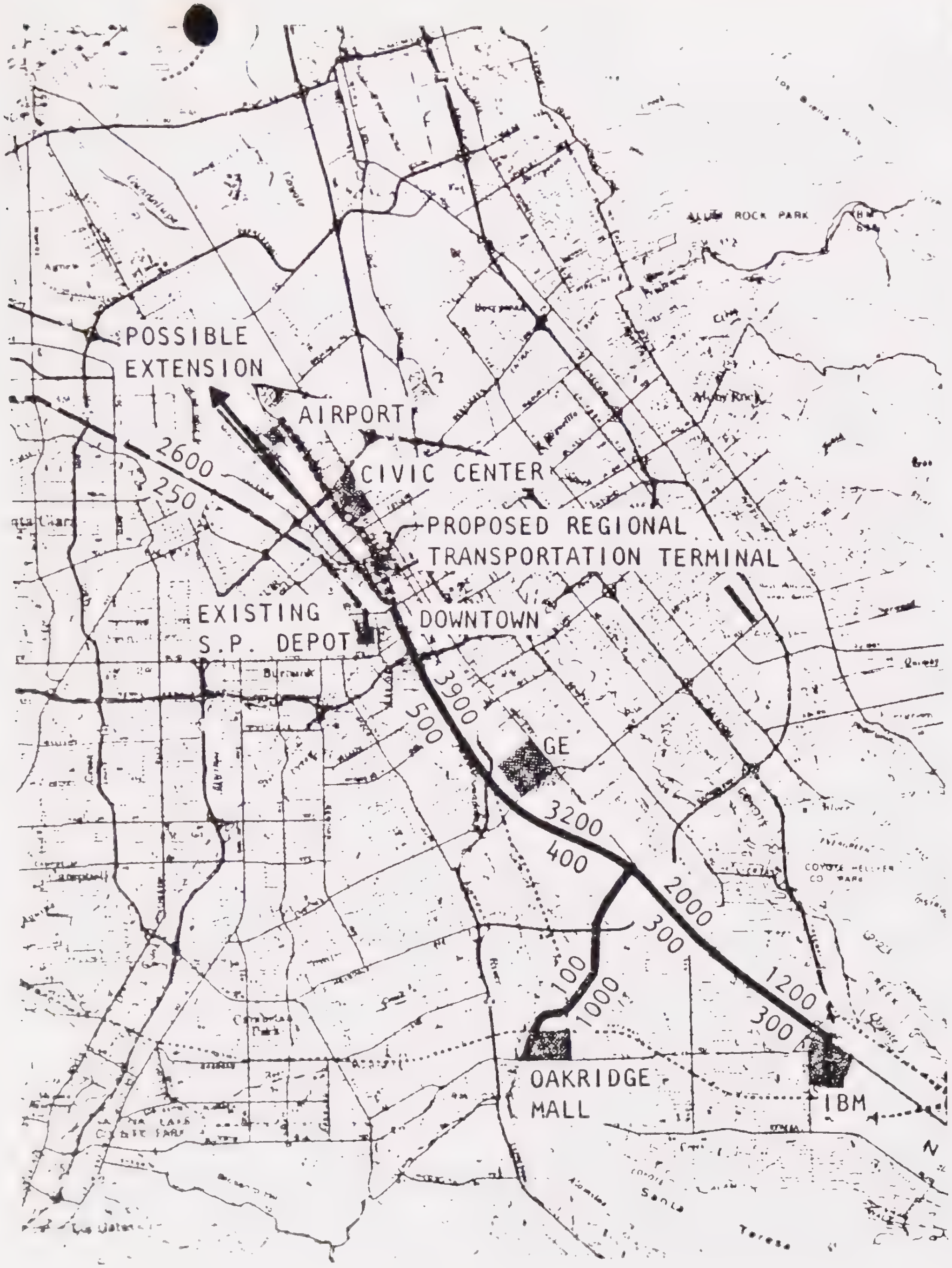

Figure 60
POSSIBLE STARTER LINE
1990 PATRONAGE FORECAST RESULTS
(Numbers shown are AM peak-hour volumes)

Figure 61
POSSIBLE STARTER LINE - SELECTED
OPERATING PATTERN AND HEADWAYS
(Numbers shown are required No. of LRV's
per hour and the resulting headways in
parenthesis)

The costs of purchasing free transfer privileges from Southern Pacific for all County transitway users in 1990 is expected to run an additional \$2.2 million (4.4 million annual riders at \$0.50 each). Thus, the total operating costs of the starter line transit improvement would be \$5.1 million in 1976 dollars, or about \$1.6 million more than is currently available under the existing five-year financial plans. The second funding constraint would thus have to be modified in order to permit long-term operations of the potential starter line as described above. However, some savings in the operating costs of the local 516-bus system should be possible due to the elimination of duplicative parallel bus routes to the transitway and these could be used to meet part if not all of the estimated shortfall. A new financial plan should also be prepared after decisions have been reached as to just what the initial starter line should encompass.

FARE REVENUE ESTIMATES

Assuming a 25-cent base fare, the light rail starter line is estimated to carry 30,000 riders per weekday in 1990, or times 286 equivalent weekdays per year, 8,580,000 riders annually. Assuming 15 percent of these riders arrive at the light rail line by bus and that there is no extra fare paid by these transferring riders, there would be 7,293,000 revenue passengers. An average fare of \$0.17 per passenger is expected to be recovered using a 25-cent base fare and the current fare discount policies for special groups. This would result in an annual fare revenue of about \$1.2 million. Compared with the estimated total annual operating costs of \$2.9 million for the light rail system plus \$2.3 million for purchase of SPRR transfer privileges, annual fare revenues would recover only 24 percent of the \$5.1 million total operating costs assuming a 25-cent fare. A 35-cent fare would lower ridership by 15 percent but increase revenues to \$1.45 million for a 28 percent recovery rate.

Table 58
ESTIMATED ANNUAL OPERATING COSTS -- LIGHT RAIL STARTER LINE

	Cost in Millions of 1976 Dollars
Maintenance of Way and Structures	$0.72
Maintenance of Transit Vehicles	0.36
Power, Fuel and Supplies	0.30
Conducting Transportation	0.74
General and Administrative	0.32
SUBTOTAL	$2.44
Contingency Allowance	0.49
TOTAL	$2.93

SUMMARY OF ANNUAL BENEFITS

The 12-mile potential light rail starter line is expected to attract 30,000 transit riders daily in 1990, 18,000 former auto users and 12,000 former bus riders. Assuming an average auto occupancy of 1.25 for the former auto users switching to transit (mostly home-work and home-school trips), approximately 14,400 auto trips per day would be saved in this corridor. During each peak travel period, an estimated 4,100 auto trips would be eliminated, or about 15 percent of the total auto trips. As a direct result, the average travel speeds on the parallel Almaden Expressway, Monterey Highway and US 101 would be expected to increase by an average of 10 MPH, from the 5-15 MPH range to

the 15-25 MPH range. Significant travel time savings would thus accrue to both continuing peak-period auto drivers and to former bus riders. In addition, some travel time would also be saved by commercial vehicles. These savings were estimated and shown in Table 59. Also shown in this table are savings which would result from a reduction in automobile use -- auto operating costs, accidents and parking lot needs. The total annual benefits which can easily be assigned a dollar value are estimated to be $12 million.

Table 59
ESTIMATED ANNUAL BENEFITS ACCRUING FROM POSSIBLE LIGHT RAIL STARTER LINE

	Annual Benefits in Millions of 1976 Dollars
Travel Time Savings	
• Continuing Auto Drivers	$ 4.23
• Former Bus Riders	1.93
• Commercial Vehicles	0.98
Automobile/Highway System Savings	
• Operating and Maintenance Costs	2.86
• Accident Reduction	0.20
• Parking Lot Reduction	1.80
TOTAL ANNUAL BENEFITS	$12.00

As discussed in Chapter VIII, Economic Feasibility, other benefits would accrue but are difficult to assign a dollar value, including non-work trip time savings, reduction in auto ownership, and beneficial land use/urban development shaping potential.

This last benefit is not only not easily quantified, but also not necessarily agreed upon by all persons as a positive benefit. It will also require actions and policies in addition to provision of a rail facility, as explained earlier. Nevertheless, the new San Jose General Plan calls for a greatly increased focus of jobs in the CBD, in the areas of south San Jose north and south of General Electric at Curtner Avenue and Monterey Highway, and in the IBM industrial park area between Cottle Road and Bernal Road. The light rail starter line could act as a catalyst in helping attract new jobs and development to these desirable high growth areas indicated in the San Jose General Plan. Also, if increased residential densities were permitted and constructed adjacent to the light rail stations instead of further low-density sprawl in outlying suburban areas, savings in city-provided streets and utilities might occur. Assuming that within the starter line corridor area there will be a projected increase in population of about 55,000 and an increase in jobs of about 35,000 over the next 15-20 years, and also assuming that a light rail transit line and positive public policies are implemented so as to bring about a doubling in the average density level at which this new population and employment growth is projected to develop, a savings of about $40 million would occur from foregoing the development of some 2,700 acres. The average residential density of all new developments would have to increase from 15 people per acre to 30, and the average employment density of all new developments would have to increase from 20 jobs per acre to 40 in order to bring about these land use/infrastructure savings.

If half of these land development savings could be attributed to the construction of the light rail starter line and they were annualized, a benefit of approximately $1.7 million per year could be assigned to the light rail system. When Denver and Los Angeles quantified these potential land development/infrastructure cost savings, they also found them to be substantial and significant.

Table 60 shows the annual dollar value estimated for these and other benefits which are much more difficult to agree on and quantify. The total annual value of these "soft" benefits is estimated to be $4.44 million and should be considered only indicative of potential "add-on" benefits.

Table 60
POTENTIAL ADDITIONAL BENEFITS OF THE STARTER LINE

	Annual Benefits in Millions of 1976 Dollars
Containment of Urban Sprawl/ Infrastructure Savings	$1.73
Reduction in Automobile Ownership (Second Car Savings)	1.28
Non-work Trip Travel Time Savings	
Constant Transit User	0.72
Constant Auto Driver	0.71
TOTAL "ADD-ON" BENEFITS	$4.44

Table 61 presents an indication of the starter line's transit service effectiveness as measured by transit incremental improvements over the Baseline 516-bus system. Note that the corridor's transit riding habit and the peak-period modal split would both jump sharply, with increases of 150 percent.

Table 61
TRANSIT SERVICE EFFECTIVENESS MEASURES -- POSSIBLE LIGHT RAIL STARTER LINE

Service Effectiveness Measures	Baseline 516-Bus	Added by LRT Starter Line	Percent Increase
Total Daily Transit Riders	120,000	+ 18,000	+15%
Total Daily Passenger-Miles	540,000	+156,000	+29%
Corridor Transit Riding Habit*	20	+30	+150%
Corridor Peak-Period Modal Split	6%	+ 9%	+150%

*Annual rides per capita in the corridor.

ECONOMIC EVALUATION

Table 62 shows the results of the economic evaluation of the possible light rail starter line. Annual benefits are estimated at $12.0 million, while annualized costs assuming a seven percent discount rate are estimated at $13.8 million, all in 1976 dollars. The resulting benefit/cost ratio is slightly less than 1.0, indicating costs would exceed quantifiable benefits. As explained previously, other benefits were identified which could be significant but are difficult to quantify in dollar terms. These have been presented separately in Table 60 under the term "Potential Additional Benefits." The Benefit-Cost Ratio derived including these benefits is 1.19, indicating that the starter line is an economically desirable investment. Because the dollar value of these benefits is not certain, the results of the benefit-cost analysis which includes them is more difficult to interpret. However, it indicates that by incorporating these benefits and other benefits such as reduction in energy consumption and noise and air pollution, which are even more difficult to quantify, a project which may not appear economically viable in strictly quantifiable terms alone may actually be an attractive investment.

Therefore the decision-maker should carefully weigh the potential value of these other benefits before reaching a final conclusion.

Table 62
ECONOMIC EVALUATION FACTORS -- POSSIBLE LIGHT RAIL STARTER LINE

Total Annual Riders	8.6 million
Total Annual Quantifiable Benefits	$12.0 million
Total Annual Costs*	$13.8 million
Benefit/Cost Ratio	0.87
Benefits Net of Costs	-$ 1.1 million
Potential Additional Benefits	$ 4.44 million
Benefit Cost Ratio with Additional Benefits	1.19
Benefits Net of Costs with Add. Benefits	+$3.44 million

* Using a 7 percent discount rate

Table 63 presents a set of various transit cost efficiency measures aimed at evaluating the worth of building an initial light rail starter line. The incremental capital costs of the light rail line would be about four times more per incremental passenger-mile that those for the 516-bus system, while incremental operating costs per incremental passenger-mile would be less than half those for the local bus system. Total system costs per passenger-mile would be about the same. However, when it comes to operating cost subsidies, the light rail system holds a clear advantage, requiring less than half as much subsidy per passenger-mile as the local bus system.

Table 63
TRANSIT COST EFFICIENCY MEASURES -- POSSIBLE LIGHT RAIL STARTER LINE

Cost Efficiency Measures	Baseline Bus System	LRT Starter Line Incremental*	Total System Combined
Annualized Capital Cost/Passenger	$0.21	$1.71	$0.41
Annualized Capital Cost/Pass-Mile	0.05	0.20	0.08
Annual Operating Cost/Passenger	$1.13	$1.00	$1.11
Annual Operating Cost/Pass-Mile	0.25	0.11	0.22
Total Annual Cost/Passenger	$1.34	$2.71	$1.52
Total Annual Cost/Pass-Mile	0.30	0.31	0.30
Operating Subsidy/Passenger	$0.96	$0.84	$0.93
Operating Subsidy/Pass-Mile	0.21	0.10	0.18

Note: All costs shown are in 1976 dollars; discount rate used was 7 percent.
*Incremental (Additions over Baseline Bus) Cost Efficiency Measures.

When the light rail starter line is merged with the Baseline Bus, the total combined system subsidy per passenger and per passenger-mile is less than that of the Baseline Bus system alone. This again clearly illustrates the choice between a capital-cost intensive transit system and an operating-cost intensive system.

It should be noted in closing that the rationale for selection of a light rail starter line presented at the end of the previous chapter is still valid and constitutes the framework for viewing the possible starter line evaluation measures presented above. Obviously, however, further refinements are needed to insure that an optimum initial segment is designated for implementation.

CHAPTER XV

NEXT STEPS

On August 25, 1976, presentation of the Alternatives Analysis results and Final Report conclusions will be made by the consultant to a joint meeting of the Transit Board and Transportation Commission. This will conclude the current Light Rail Feasibility and Alternatives Analysis Study by the consultant.

This chapter is an attempt to describe the "next steps" in this project as they are now perceived. These relate to the following four areas which are described in subsequent sections:

- Next Steps in Light Rail Feasibility Project
- Relationship to MTC PENTAP Project
- Relationship to ABAG/MTC Santa Clara Valley Corridor Project
- Seeking Early UMTA Reactions

NEXT STEPS IN THE LIGHT RAIL FEASIBILITY PROJECT

Table 64 shows the sequence of events following the August 25 consultant presentation which are necessary before any final action on the project can be taken by the Transit District Board of Supervisors. This schedule was adopted by the Board at their July 26 meeting and calls for a series of public review and discussion meetings to be held in each of the County's fifteen cities between September and November. Both the Consultant and Transportation Agency staff will be available to present the study's key findings and answer questions at these meetings. Also during this time a Draft Environmental Impact Report (EIR) for the Transit Alternatives will be prepared and distributed to all the cities and interested citizens in order to fulfill California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) requirements.

Table 64
PROPOSED SCHEDULE FOR CITY AND PUBLIC REVIEW OF LIGHT RAIL FEASIBILITY AND ALTERNATIVES ANALYSIS

August 25, 1976	Joint meeting of the Board of Supervisors and the Transportation Commission to discuss the "key" findings and the final report.
September-November 1976	Distribute study summaries. Cities hold public discussions and conduct public meetings. Cities complete review and formulation of recommendations relative to the study findings and conclusions.
October 1976	Distribution of a Draft EIR on Alternatives.
December 15, 1976	Submission of recommendations by each City.
January 3, 1977	Board of Supervisors Public Hearing on Draft EIR on Alternatives.
February 1, 1977	Complete preparation of a Final EIR, Summary and recommended Action Plan incorporating the Consultant's findings and the recommendations submitted by each City.
February 23, 1977	Approval by Transportation Commission of a Final EIR, Summary and Action Plan.
March 7, 1977	Approval by the Board of Supervisors of Final EIR on Alternatives and a Final Summary and Action Plan.
March 28, 1977	Incorporate the Final EIR, Summary and Action Plan in the Transportation Improvement Program for transmittal to MTC for current regional TIP.

Responses and recommendations from each of the cities are due by December 15. On January 3, 1977, the Transit District Board of Supervisors will hold a public hearing on the Draft EIR for the Transit Alternatives. Upon completion of the hearing a period of 60 days will be reserved for receiving public feedback and comments on the Draft EIR. During this time a Final Project Summary, Final EIR and recommended Action Plan incorporating the Consultant's findings, recommendations submitted by each city and citizen inputs will be prepared. These will be submitted to the Transportation Commission for their review and recommendations to the Board.

On March 7, 1977, the Transit Board will meet to review and approve the Final EIR on Transit Alternatives. Upon making this approval the Board will be in a position to adopt a Final Project Summary and Action Plan. These will all be incorporated into the current Transportation Improvement Plan (TIP) for the County and submitted to MTC for adoption and incorporation into the regional TIP. Such action would put the Transit District in a favorable position to pursue a Federal capital grant application for any transportation improvements recommended as a result of this project.

As part of completing and adopting a Final Action Plan, a revised financial plan should be prepared for the Transit District. This should be done to assure that the necessary local share of the capital and operating costs for the recommended transit improvements will be available on a timely basis to pursue their implementation and continued operation.

RELATIONSHIP TO PENINSULA TRANSIT ALTERNATIVES PROJECT (PENTAP)

MTC is currently conducting an extensive study of long-range transit alternatives for the regional transportation corridors between San Jose and San Francisco and San Jose and Fremont (current BART terminus). This study has a direct bearing on the potential success of any transit improvements in the five corridors studied, as more than 40 percent of the potential

transit riders in these corridors would be affected by the assumption of a convenient transfer to an improved Southern Pacific Peninsula train service or an equivalent transit facility. The implementation of a light rail starter line would act as a transit extension or feeder line to this regional trunk line and likewise serve as a distribution link for passengers traveling south to the San Jose area. The two transit services would thus be mutually supportive and reinforcing. Without a convenient and low cost transfer to this key regional transit link, however, the ridership potential and the correlated transit benefits of a starter line would be seriously undercut.

The MTC PENTAP study is now in the analysis and evaluation phase of the regional transit alternatives for these two corridors and is due to be completed by January 1, 1977. It is hoped that the study will address effective interface/transfer arrangements with a possible Santa Clara County transitway system in the vicinity of downtown San Jose as well as the increased ridership potential from such an arrangement.

ABAG/MTC SANTA CLARA VALLEY CORRIDOR STUDY

This project is just now (August 1976) in the process of getting underway and will consider a wide range of possible long-range land use/development and transportation scenarios for the Santa Clara Valley. The study will be a comprehensive one, exploring the constraints and trade-offs between environmental, social and economic considerations. From these several scenarios, two or three alternatives will be selected for detailed analysis and comparative evaluation. It is MTC's intention that this regionwide study will fulfill the Federal Urban Mass Transit Administration's requirements for a regional Alternatives Analysis. This Alternatives Analysis requirement must be satisfied under current Federal guidelines before any major capital grant application for fixed guideway facilities can be approved. Thus both the fulfillment of this requirement and the recommendations which come out of the ABAG/MTC Santa Clara Valley Corridor Study are critical to the implementation of the Final Action Plan of this project. This study is due to be

completed by October 1977, but by March 1977, the land use/development and transportation alternatives analysis is scheduled to be sufficiently advanced to enable both the local and regional decision makers to assess whether the Final Action Plan for this project will be compatible with the final outcome and conclusions of the regional Santa Clara Valley Corridor/ Alternatives Analysis study.

SEEKING EARLY UMTA REACTIONS

Although Federal officials have indicated that a regionwide alternatives analysis must be completed before any capital grant application for major fixed guideway facilities can be acted upon and approved, it is believed that Santa Clara County should take the information at hand from this and previous projects and the approved Final Action Plan and approach UMTA as soon as possible to determine whether or not the County will be wasting its time pursuing a Federal capital grant application to fund the recommended transit improvements if these were to include a light rail element.

UMTA has recently turned down the Denver Region's request to fund a light rail starter line after they had completed millions of dollars worth of studies including a well-received alternatives analysis, had achieved a commitment for the local funding share, apparent community commitment for transit reinforcing land use plans, and indications of a commitment to use tax-increment financing proposals. UMTA reasons given in the Denver turn-down and the Buffalo approval of a light rail starter line include such factors as population density, size of the downtown CBD employment, ease of automobile access, expected number of daily riders in the short-range, and the total annualized costs per passenger carried (cost-effectiveness). It is believed that Santa Clara County now has all of this information in hand and should seek an UMTA ruling as to whether or not Santa Clara County's population density, CBD employment, automobile speeds and accessibility, expected number of transitway riders in 1990, and the annual costs per passenger carried fall above or below UMTA's thresholds for criteria used in approving or denying capital grants for fixed guideways in Denver and Buffalo.

An early reaction by UMTA could be instrumental in helping to avoid the wasting of scarce funds on pointless additional studies and/or could help focus the County's efforts most productively. This might include seeking revisions to present procedures for allocating Federal transit funds, seeking legislation which would provide additional funds at Federal, State or local levels, or accepting this funding constraint and re-orienting the Final Action Plan as required to make improved public transportation an implementable reality with realistic, fundable projects.

The County can only gain by trying to get an early formal reaction from UMTA as to whether or not any fixed guideway grant funds are still available for Santa Clara County, whether or not Santa Clara County has a chance at meeting UMTA's threshold criteria and thus qualifying for a fixed guideway capital grant, or what other specific pieces of information are required before the County would become eligible to receive such grant funds. If no more funds are available for the current five-year funding program which ends in 1980, Santa Clara County may still wish to lobby for additional Federal transit funding legislation and get its capital grant application in and tentatively approved so that it will be in a favorable position should future capital grant funds become available. Interim improvements in bus service should, of course, continue to be actively pursued in accordance with Transit District policy.

APPENDIX

LIST OF PROJECT DOCUMENTS

In addition to this Final Report, project documentation includes a variety of working papers, memoranda and correspondence, the more important of which are listed below and which can be found in the project file.

Project Working Papers

No. 1 Functional Design Criteria, January 1976
No. 2 Travel Market Potential, March 1976
No. 3 Alignment Definition, April 1976
No. 4 Environmental, Socio-Economic and Land Use Impact Assessment, May 1976
No. 5 Patronage Forecasts, June 1976
No. 6 Capital and Operating Costs, July 1976
No. 7 Alternatives Analysis, August 1976

Consultant Technical Memoranda

Analysis of Transitway At-Grade Crossings and Traffic Impacts
Transit Vehicle Selection, Procurement and Costs
Transit Vehicle Power Supply and Electification System
Transit Vehicle Control and Communications System
Transit Vehicle Yards and Maintenance Facilities
Adjusting and Verifying the Transit Modal Split Model

County Transportation Agency Technical Memoranda

Five-Year Transit Improvement Program (T.I.P.) and Accompanying Financial Plan
TSM Alternative -- Reserved Lanes for High Occupancy Vehicles
TSM Alternative -- Bus Traffic Signal Pre-emption
TSM Alternative -- Cal Trans Freeway Ramp-Metering Program
Discussion of Labor Peace
Tax-Increment Financing Methods applied to Transit
Legal Opinion RE: Possible Railroad Line Buy-Out and Operation by Transit District
Impacts on Transit District Assuming Different Possible Railroad Buy-Out Options

Selected Correspondence

"Light Rail Notes," Project Newsletter. Monthly issues were distributed to a large number of interested community action groups and citizens. SCCTA Public Affairs Staff.

"An Analysis of Land Costs of Alternative Projects in the WVTC." Ralph Ballmer, Sierra Club, December 5, 1975.

Comments on Fixed-Guideway (Light Rail) Feasibility Study. Richard Brown, December 18, 1975.

Letters inviting affected city engineers to attend a staff briefing session. Louis Montini, SCCTA, February 5, 1976.

Comments on "SCCTD Light Rail Feasibility and Alternatives Analysis." A.L. Spivak, Chairman, Hardware and Technology Committee, February 11, 1976.

Response to Mr. Spivak's letter of February 11, 1976. Walter Kudlick, De Leuw, Cather & Company, March 8, 1976.

Comments and Viewpoints Concerning the Light Rail Feasibility Study. John C. Beckett, February 23, 1976.

Response to Mr. Beckett's letter of February 23, 1976. Walter Kudlick, De Leuw, Cather & Company, March 8, 1976.

Comments on Working Paper No. 1. Ralph Ballmer, Light Rail Coalition, February 28, 1976.

Letter objecting to elimination of consideration of highway alternatives in the WVTC. Russell Cooney, Los Gatos Town Manager, March 12, 1976.

Proposal for a Major Regional Transportation Terminal Near Downtown San Jose. James Self, San Jose Councilmember, March 8, 1976.

Letter requesting the Transit District to consider and study Councilmember Self's proposal. Janet Gray Hayes, Mayor of San Jose, March 23, 1976.

Letter stating concern of City of San Jose re: highway/street capacity and level of service assumptions. Ted Tedesco, San Jose City Manager, March 30, 1976.

Responses to Mr. Tedesco's letter of March 30, 1976. Louis Montini, SCCTA, April 1976.

Letter re Ongoing Trasnportation Studies and Achievement of the 30 Percent Riderhsip Objective. Ralph Ballmer, Sierra Club, May 3, 1976.